DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

SEPTEMBER 1959

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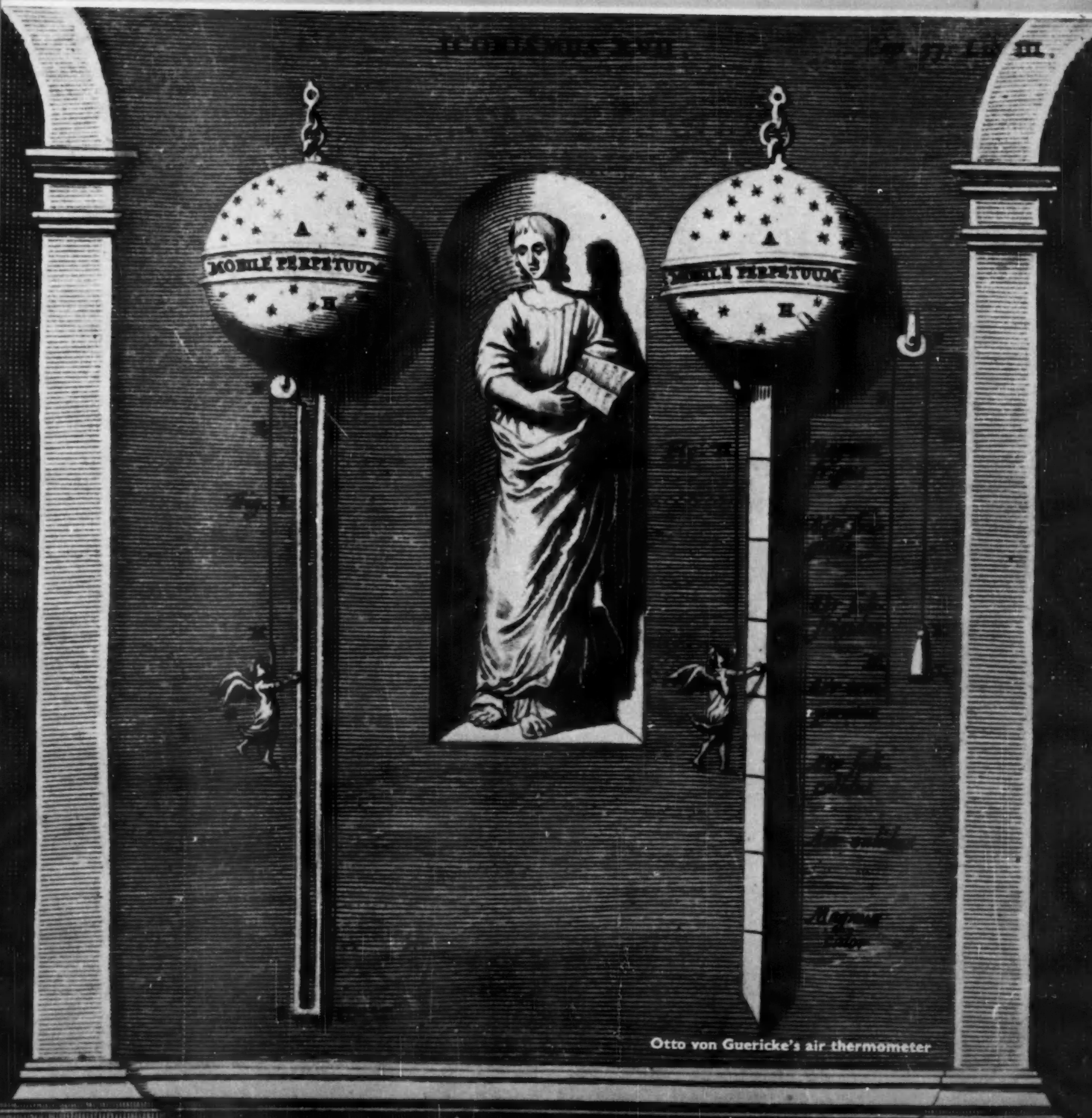

Otto von Guericke's air thermometer

DISCOVERY

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Editor

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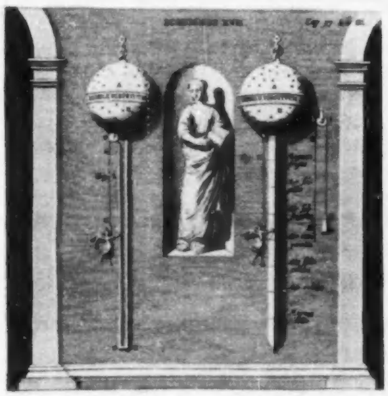

Otto von Guericke's improved air thermometer. The U-tube on the left was filled with alcohol which supported a small piston in the left limb of the tube. The piston was suspended by a fine thread from a wheel, with the figure of an angel acting as a counterpoise. According to the expansion of the air in the sphere the liquid was displaced, the piston moved up and down, and the angel indicated the temperature. (From "Experimenta nova, ut vocantur, Magdeburgica de vacuo spatio", Amsterdam, 1672.)

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THE PROGRESS OF SCIENCE

SCIENCE AND CRIME

Crime is a most confused area, not only in its own nature but also in respect of the disciplines which must be mastered for its study—law, morals, statecraft, medicine, psychiatry, sociology, all of which play their diverse roles. It is therefore important to ensure not only that there is the maximum application of science within these provinces, but also that the scientific method is deployed to gain a general synthesis of our objectives.

In the past, attention was focused on the role of science in the detection of crime. The endless complexity of life has made detection based on human evidence increasingly fallible, and the fight against crime will depend more upon circumstantial evidence obtained by scientific analysis and evaluation. While the growing use of the Home Office Police Laboratories indicates the importance of the forensic scientist, it is salutary to reflect that despite the more intensive application of science to the combating of crime the proportion of offences cleared up by the police continues on the face of it to decline: it was 47·2% in 1957, compared with 50% in 1938. Given that the ratio of police to population is higher than pre-war, could this mean that the police are becoming less efficient, or that society is faced with a genuine increase in crime?

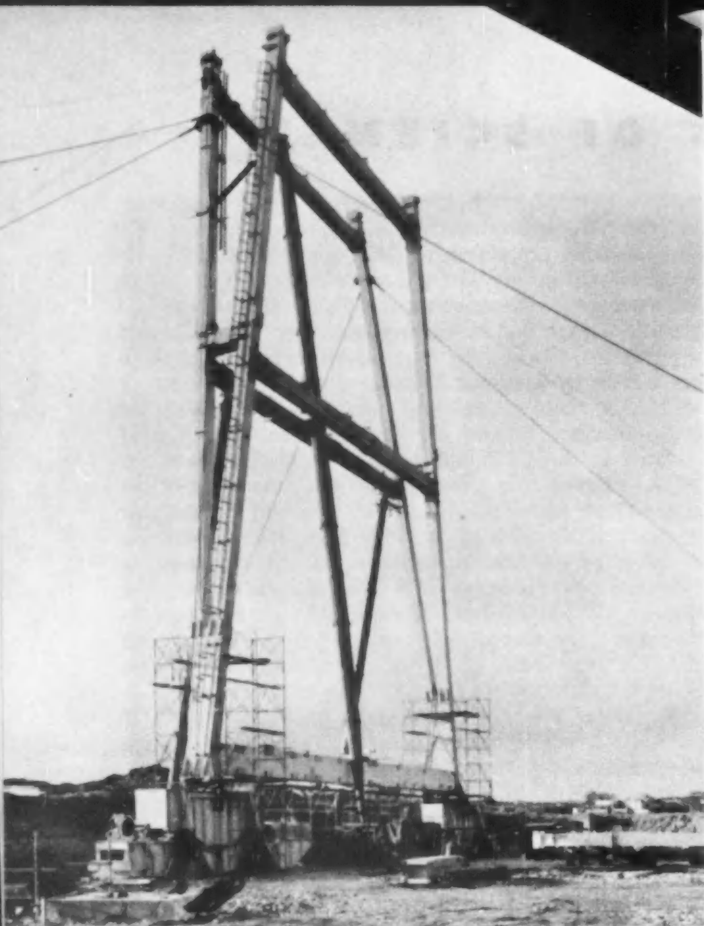
Numerous provocative questions suggest themselves and as a prerequisite, postulate an intensive study of criminal statistics to determine how far there really has been an increase in crime. This exercise itself is less simple than would appear, for though criminal statistics are in some respects extremely detailed and comprehensive, their validity is restricted by the terms and definitions used by the particular agency producing them. Incidents recorded by the police and convictions reported by the courts may or may not be a valid measure of criminality, but there must be much undetected and unreported crime, not to mention criminal intent, which enters into the equation. The problem becomes even more complex when the causation of this supposed increase, and remedies for this are under review.

Generalisations abound, some worthy though utterly unfounded in character: economic progress, increased urbanisation, the move to suburbia, the growing prosperity of young people, the nature of mass cultures, the elevation of violence, the decline of religion, the weakness of the police, the nature of the individual personality, the prevalence of broken homes, the character of parents, are diagnoses which could well be partial and inconclusive. That car-stealing among youth is much more prevalent in Scandinavia than in Britain, but that it has recently shown a remarkable increase here, could reflect the growing use of cars in this country, a deep difference in criminality between Britain and Scandinavia, or some quite unexpected hypothesis. Let us admit that we do not know the answers, and concede that a more effective study of criminal statistics in the widest sense is overdue.

The scope for research does not end with the cataloguing of crime, for society is also involved in the fate of the criminal after apprehension—his sentence and his re-integration in society. Here, too, it can be argued, though not necessarily with universal acceptance, that the judicial process—sentencing, remissions, and even after-care and supervision—follow their own established norms and do not necessarily work out in a way which is best either for society or the criminal. We naturally welcome recent recognition both official and general of the importance of research in these fields—the Government's White Paper "Penal Practice in a Changing Society", the work of the Home Office Research Unit, the establishment of the new Institute of Criminology at Cambridge, are all valuable testimony to this trend. Nevertheless, we must recognise the paltriness of our current efforts. An expenditure on field research of £20,000 on the Home Office vote may be contrasted with an annual outlay of the whole prison service of £14 million, rising next year to £17·5 million, and an estimated £15 million annually lost in goods stolen in transit alone! Some American states are allocating 2% of their prison expenditure to research. One is bound to ask whether our society has its priorities right.

For all that it should not be thought that research provides an automatic panacea. The fields to be surveyed are vast and the variables innumerable. That progress can be made in the study of prediction of risk categories, particularly in laying down the best lines of treatment, is now widely recognised. But this is essentially a limited operation. Inevitably we have to know more about causation, and it is here that caution beckons. Attempts to establish socio-economic bases of causation have foundered on the extreme variability of the data and the running has hitherto been made by the psychiatric or medical experts who view criminality as a facet of the individual character. "Treat them young" is a popular slogan in which there may well be some force, and yet it should not be forgotten that crime cannot be fully understood purely in terms of the perpetrator but must also be assessed in terms of the society in which it is committed. The attempt to cure crime or to help the criminal may involve modifications of certain social institutions, and the question arises: is this possible? We are inevitably driven to a study of deterrence in relation to crime. What is its role? What is the nature of social cohesion? What measures are necessary for the defence of society? The framing of answers involves a study of such disparate topics as the nature of morality against its social and individual backgrounds, and psychiatric and medical aspects of human beings.

The range of such problems seems so overwhelming that we wonder if progress can be made at all. That such tasks deserve a due measure of humility is conceded, but we are not defeatist about the potential achievements of science. We believe that the reconciliation of problems of morality and man's nature involved in the study of criminology can help not only to the solving of this problem but hold the key to still wider aspects of the *condition humaine*.



A Crane Erects Itself

Not since the construction of railways over a hundred years ago has Britain seen such major civil and mechanical engineering works as the building of the atomic power stations for the Central Electricity Authority. The biggest power station is the one at Hinkley Point (DISCOVERY, 1957, vol. 18, p. 454), and on the cover of the November issue of that year we showed an artist's impression of the most spectacular aspect of the power station: The Goliath Crane. This giant, undoubtedly the biggest crane in the world, has now erected itself, it has been tested, and it is ready to play its important part in completing the erection of the power station.

The structure, manufactured by Babcock and Wilcox Limited, towers to an overall height of 240 ft. above ground-level and has a span of 250 ft. between the legs. It is capable of lifting loads up to 400 tons by means of two 200-ton lifting-hooks each operated by its own hoisting gear and control cabin. The two hooks can be used as independent units, or their operation synchronised so that both hooks are controlled as a single unit, thus enabling the heavier loads to be lifted. The lifting-speed is about 4 ft./min., which means that the crane will take nearly three-quarters of an hour to lift a load of 400 tons to its maximum height.

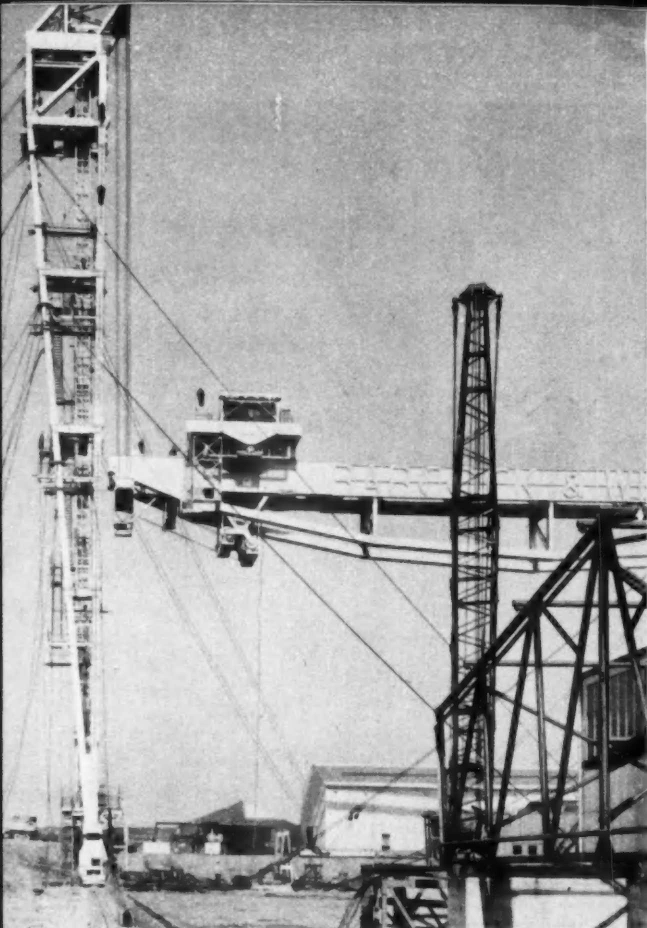
The crane can traverse the power-station site for a distance of over 500 yds. from the assembly and fabrication area to beyond the two main reactor buildings, and its great height will enable it to straddle and clear adequately the top of the reactor buildings, both of which will be 180 ft. high. Thus, it will greatly facilitate the erection of the large amount of heavy plant and material, since major units of equipment, such as steam-raising units and reactor pressure vessel sections, can be partly or fully assembled and fabricated on the site assembly area and carried thence by the crane to their final positions.

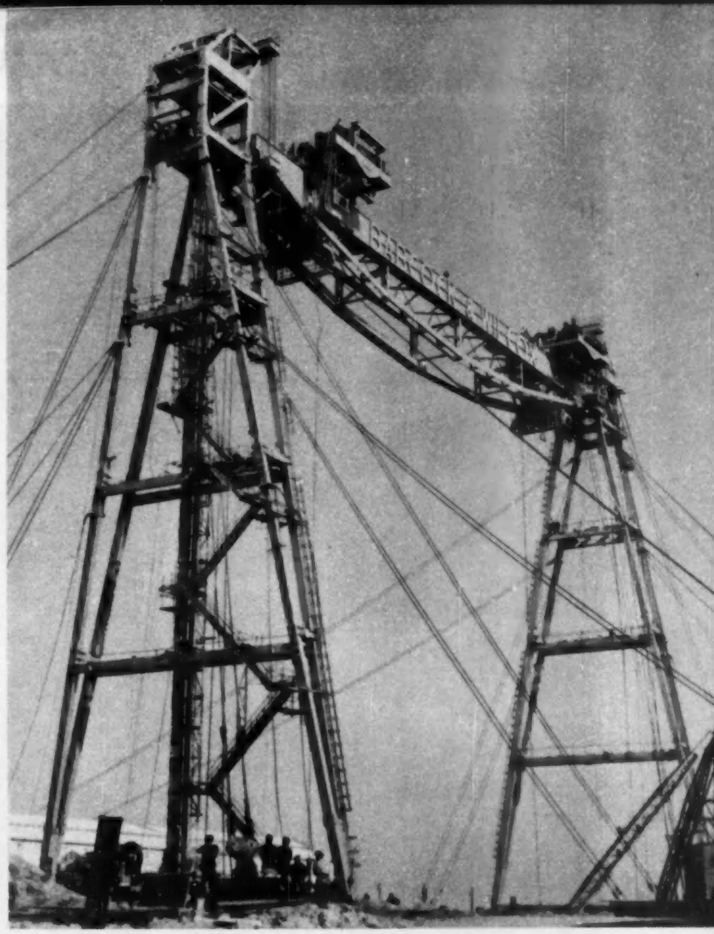
Each leg is mounted on two self-compensating bogies running on single-line railway track. The bogies are electrically operated, and special means are provided to synchronise the movement of the legs while the crane is travelling. The crane will travel at up to 50 ft./min., a speed of just under a half-mile an hour, when carrying the heaviest loads envisaged, about 380 tons.

It is an important feature of the design and construction of the crane that it can be dismantled for transport by road, rail, or sea for re-erection and use on other constructional undertakings. To achieve this, the 250-ft.-long main girder or "bridge" and the 250-ft.-high biped legs are divided into a number of sections of a size convenient for normal transport; over 1600 tons of metal has been used in its construction.

The hoisting gear consists of two "crabs", each controlled from its own driver's cabin, and equipped with 10-ft.-diameter hoist drums electrically driven through gearing. Communication from the ground with each of the two drivers is by telephone, and special safety devices will prevent any misunderstanding of signals between the drivers or between the ground personnel and the drivers. A lift is installed in one of the legs to take the drivers to and from the top of the crane.

Erecting a crane of this magnitude required much



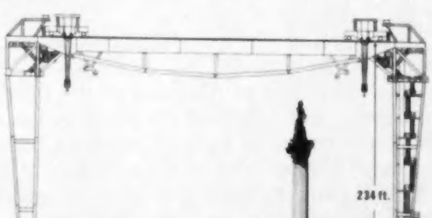


ingenuity. For this purpose, each leg was erected section by section and temporarily guyed by steel ropes, in the vertical position.

The complete bridge, weighing over 640 tons, was lifted 240 ft. to its final position, using its own hoisting gears, which were in position on the bridge. In effect, the crane "lifted itself by its own bootstraps". This spectacular operation was completed in just over an hour.

When the bridge was hoisted to its full height, the legs were allowed to tilt inwards to their final positions, by progressive slackening of the outer guy ropes, until the ends of the bridge were resting on their bearings and the whole structure was finally secured.

The crane has now been tested in all its movements, the communication system checked, and test-loads applied. It stands as a spectacular landmark on the Bristol Channel ready for its task of erecting the world's largest atomic power station.



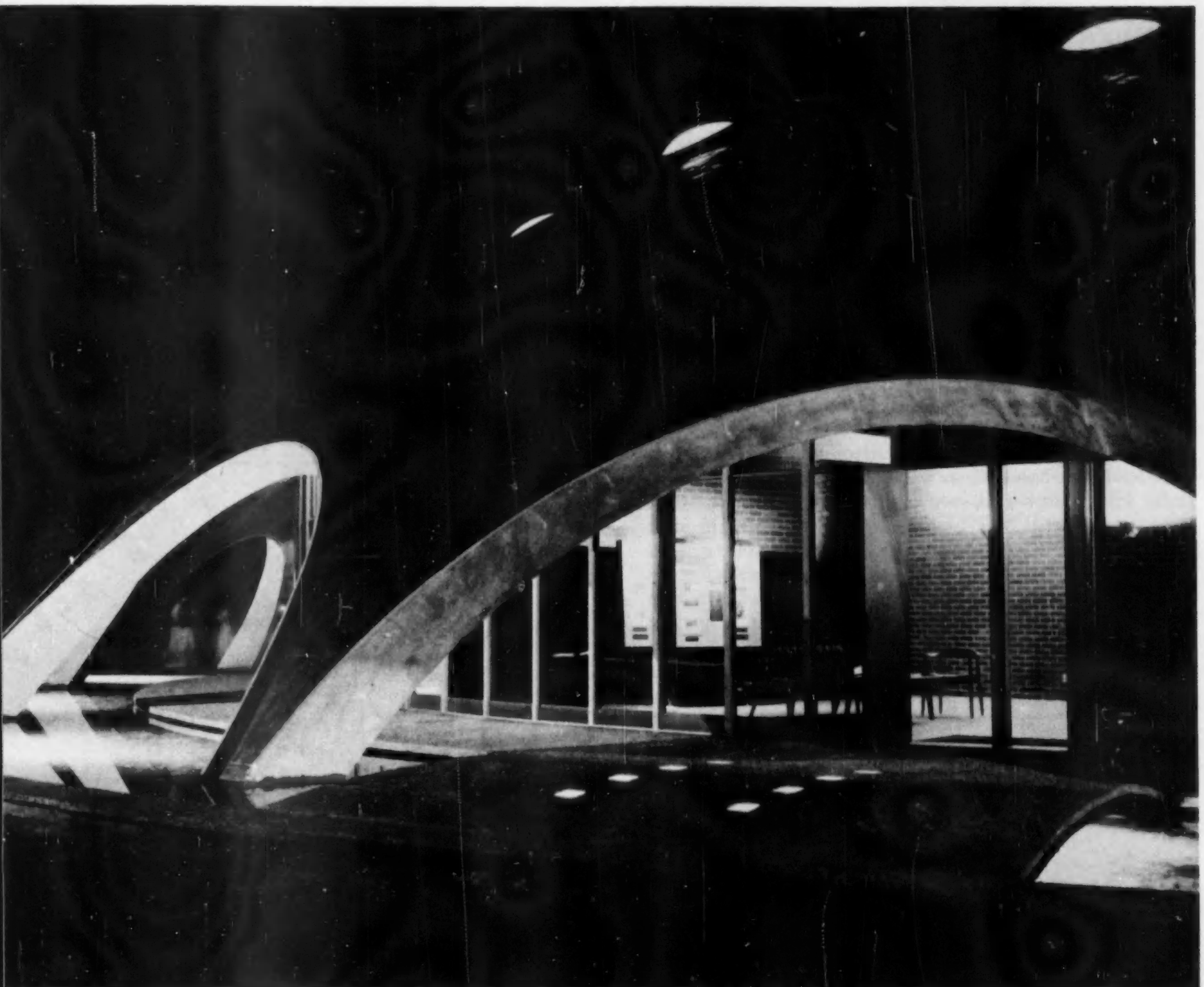
The Academy building consists of a massive dome 156 ft. across the base and surrounded by a narrow moat. The dome is of concrete covered with copper sheets, resting on arches set in the moat. The building is ringed by a natural setting of gum-trees.

AUSTRALIAN ACADEMY OF SCIENCE

On May 6 the Governor-General of Australia, Field-Marshal Sir William Slim, opened the new building which houses the offices and conference chamber of the Australian Academy of Science. The establishment of the Academy was initiated by a group of Fellows of the Royal Society of London resident in Australia. With the help of other Australian scientific leaders, they set up a body which received a Royal Charter from Her Majesty Queen Elizabeth II during her Australian tour in 1954.

The Australian Academy of Science is the representative body of Australian scientists at the national level, with functions comparable to those of the Royal Society of London, which was itself represented at the opening by its senior Vice-President, Sir Lindor Brown. The Academy consists of Fellows who are chosen because of their eminence in some branch of the physical or biological sciences in Australia. At present they number eighty-seven, and six new ones may be elected annually. They occupy professional positions in universities, in research organisations, and in industry. The President of the Academy since 1957 has been Sir John Eccles; his predecessor was Sir Mark Oliphant.

The objective of the Academy is, in general terms, to promote the acquisition of scientific knowledge in Australia and the application of this knowledge towards the fruitful development of the country and its resources. It is the representative institution of Australia on the International Scientific Unions, and organised the participation of some hundreds of scientists from research institutes, universities, and government departments in the activities of the IGY in 1957–8. It is currently arranging specialist international symposia in biochemistry and the chemistry of natural products, and was responsible for the recent successful meeting of the Special Committee on Antarctic Research in March 1959.



The only entrance to the Academy building is across this bridge over the moat.

In addition, the Academy has sponsored reports on scientific manpower in Australia, on man and animals in the tropics, and on hydrology, a subject of great importance to Australia because of her slender water resources.

Within five years of its foundation the Academy has constructed a home for itself, illustrated in these pages. The copper-sheathed dome of the building, rising from the waters of a surrounding moat, is backed by the rolling bronze-green hills of Australia's national capital, Canberra. Beneath the dome is a central conference chamber, with luxurious seating for 150 and comfortable seating for a further 150, and a ring of offices, a council room, and a superb reception room which overlooks an expanse which will within a few years be part of the central lake system of Canberra. The conference chamber will be the venue of the annual meetings of the Academy itself, and will be extensively used for meetings of different Australian scientific and professional societies, as well as for such international symposia as may be held in Australia.

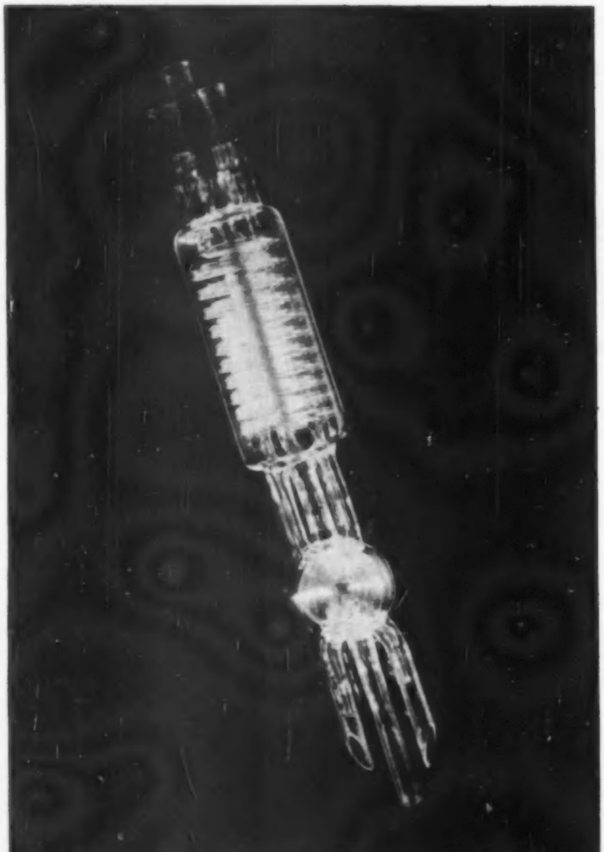
The national responsibilities of the Academy receive material recognition from the Commonwealth Government in the form of an annual grant towards current expenses. The Academy, however, remains autonomous, and indeed the value of its services derives very largely from its autonomy. It is too young a body to have achieved financial self-sufficiency through endowments, but the erection of the conference chamber and offices has been made possible by generous contributions to the Academy building fund by Australia's great industrial firms. To these firms, to the architects, and to the vision and energy of the members of its early councils, the Australian Academy of Science, and Australia, owe a debt of gratitude; for they have created one of the most striking and important structures in Canberra, and they have provided the Academy with a home of its own which is modern, dignified, and of the highest quality.

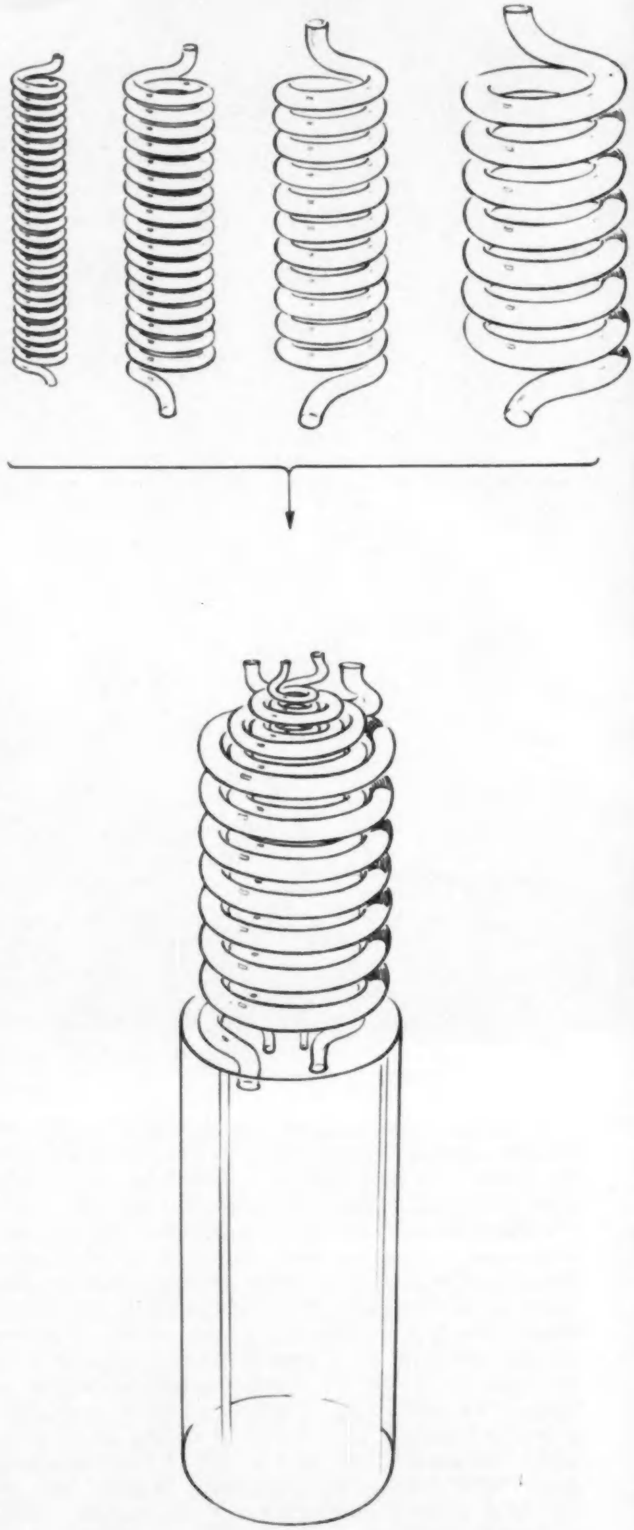
A MULTIPLE SPIRAL AND BALL CONDENSER

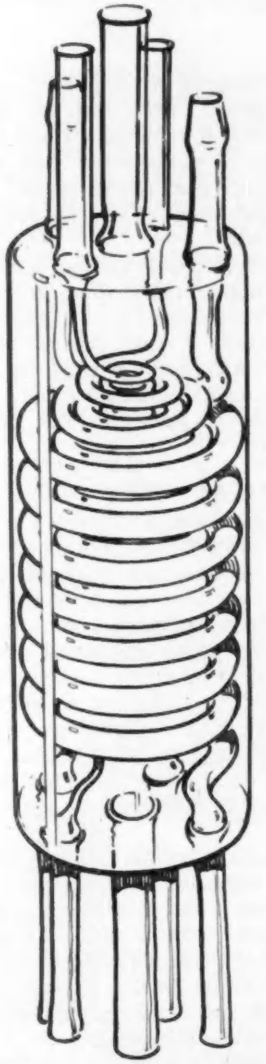
The Ball spiral condenser was constructed by a Mullard apprentice, Mr A. Moore, for the Physical Society Competition, 1959, where it received the first prize for The Craftsmen and Draughtsmen Competition for Apprentices. It was then exhibited for a time at the Science Museum, South Kensington and at the Glass Industries Exhibition. It is to be permanently housed at the Mullard Laboratories, Salfords, near Redhill, Surrey.

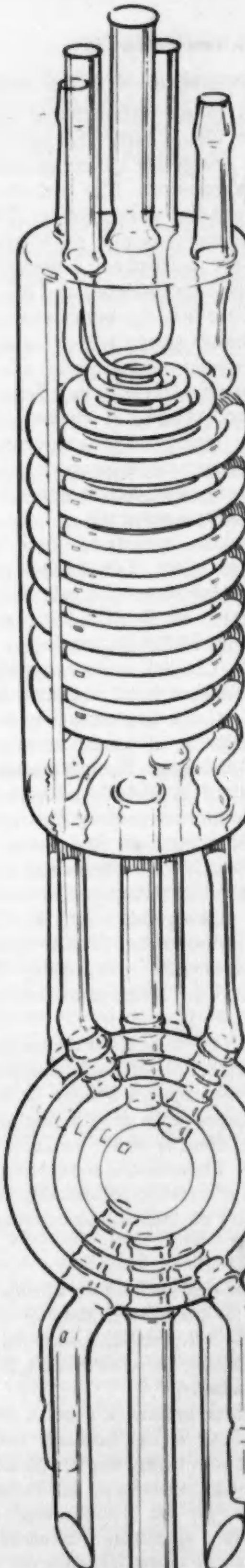
The construction was in the following order. First, the spiral winding consisted of selected diameter tubing so that the spirals fitted close inside each other. The winding of the spirals was completely freehand without the use of a machine. Then the outer case was selected and the spirals packed inside. One end of the case was sealed over on to the spirals and the outer stems joined on. This was repeated at the other end of the condenser.

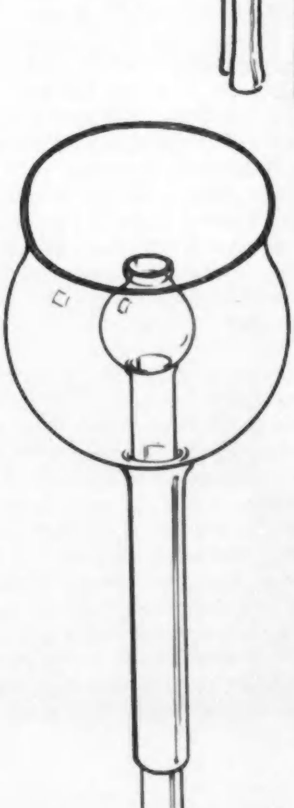
We then go on to the Ball condenser, which again was completely freehand. First, a small sphere was blown and stems joined each end, which in turn was placed into a larger sphere that was blown in open-end form to start with, and then closed over on to the smaller sphere. This was repeated five times. When completed the Ball condenser has a stem feed in and out of each sphere, which in turn are joined to the spiral condenser, thus completing the condenser.

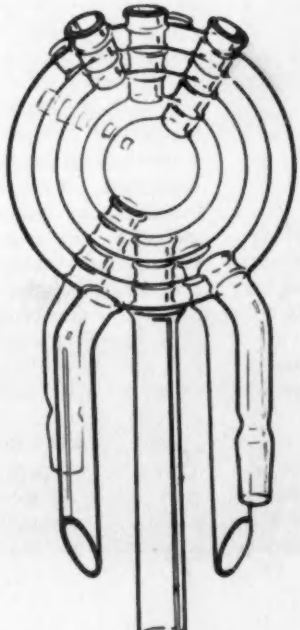












IAEA MISSION VISITS ASIAN COUNTRIES

A mission of the International Atomic Energy Agency (IAEA) left Vienna earlier this year to study the possibilities of nuclear energy for industrial and other development in four Asian countries. The first of a series envisaged for 1959, this mission visited Burma, Thailand, Indonesia, and Ceylon, before returning to Vienna. Undertaken at the request of the governments concerned, it advised IAEA on the needs of four countries and it indicated to the governments how the new Agency can assist them.

The mission's survey will probably be a pattern for later similar missions and covered all those sectors of the general economy likely to be affected by the use of atomic energy. For example, it studied the use of isotopes in agriculture, biology, and medicine; the development of reactor projects and research programmes; the training of technical manpower; health and safety standards; and the availability of raw materials.

The mission comprised four experts, namely, Dr Hugh Belcher of the United Kingdom, Dr Georges Bigotte of France, Maheshwar Dayal of India, and Prof. Oleg Kazatschovsky of the U.S.S.R., and it was staffed by members of the IAEA Secretariat.

Although only yet in its second year, the Agency has already established itself as a successful go-between. As a case in point, the Japanese Government has agreed to purchase 3000 kg. of natural uranium in ingot form from IAEA at $35.50 a kg. The material was requested by Japan for the use of a 10-MW natural uranium heavy-water research reactor, designed by the Japanese Atomic Energy Research Institute. At the same time, the Agency's 23-nation Board of Governors has accepted Canada's offer to the Agency of three tons of natural uranium free of charge. In making this offer, the Canadian Government expressed the hope that IAEA should sell it "at a price bearing a reasonable relationship to the current world price". Hence the Board has accordingly fixed the selling price at $35.50 a kg.

In addition to its world-wide missions, the Agency is by no means neglecting advanced studies among the scientists of Europe. Meeting in Vienna in January, the Board of Governors approved a programme and the budget for five scientific conferences on the peaceful uses of atomic energy during 1959. These conferences have drawn together specialists from a number of international organisations, and the catholicity of their subject-matter is evident from the following list:

(1) A three-day seminar in Vienna which began on February 25 on the scanning of medical radioisotopes; forty-five experts discussed the latest techniques for determining the distribution of radioisotopes in the human body.

(2) A seminar at Saclay, France, during July, on training specialists in the peaceful uses of atomic energy, when about eighty experts participated.

(3) A six-day conference in Warsaw, planned for September, on the use of large radiation sources in industry, especially chemical processes. Three hundred or more delegates are anticipated to attend.

(4) A symposium on radioactive metrology, the science of weights and measures, to be held in Vienna in October. There will be about 100 participants, mainly from national laboratories. The standardisation of radioisotopes will be discussed, and it is hoped that internationally accepted methods of standardisation will be established as a result of the meeting.

(5) A conference in Monaco some time in November will consider radioactive waste disposal. This conference will supplement the study already being made on the question of waste disposal in the sea by a panel of IAEA experts, and will bring together scientists from the major atomic energy establishments, oceanographers, geologists, and other experts in related fields.

"CHEMICAL ENGINEERING PRACTICE"

With the publication of Volume 6 of "Chemical Engineering Practice" the half-way stage has been reached in what must be one of the most ambitious projects in technical publishing which has ever been undertaken in this country. It is of special interest that the production of an encyclopaedic work of this magnitude (twelve volumes each of 600–700 pages) should be in the field of chemical engineering—a field in which, in the past, so much has been left to the United States in the publishing of text and reference books. The twelve volumes of "Chemical Engineering Practice" therefore, when finally completed, should help to raise the prestige of British chemical engineering throughout the world.

Contributions to the various volumes have come from chemical engineers from all over the country, both in industry and in the universities. The series is published by Butterworths Scientific Publications, under the general editorship of Herbert W. Cremer. The managing editor was originally Trefor Davies, but after his unfortunate death the difficult task of editing the volumes which remain has been taken over by Sydney B. Watkins, Head of the Department of Chemical Engineering at King's College, London. It is to be hoped that this regrettable interruption will not delay the progress of the work too much.

It is beginning to be widely appreciated that, in addition to the three well-established primary technologies, as they are called, of civil, mechanical, and electrical engineering, chemical engineering has a claim to be regarded as a fourth such technology. For this reason, the publication of a comprehensive work on chemical engineering is to be welcomed. Because of its comparative newness, the boundaries of chemical engineering are not sharply defined, and some may indeed feel that the editors of "Chemical Engineering Practice" have covered too wile a field. It is commonly thought, for example, that the specific field of chemical engineering is that of the so-called unit operations: those physical processes which are carried out on the raw materials in the manufacture of chemicals; for example, drying, distillation, filtration, mixing, and crystallisation. It is true, of course, that the chemical engineer needs in practice to have a working knowledge of many other subjects, ranging from the properties of the materials used in the construction of chemical plants, to the factors which influence the choice of the location of such plants. It is probably because of this that subjects such as these are

included in "Chemical Engineering Practice" though they could hardly be regarded as chemical engineering.

The arrangement of the material in the volumes may seem a little unfamiliar to many chemical engineers, since it is not based on the widely accepted concept of the unit operations, nor on any of the perhaps more fundamental groupings of these unit operations which have been suggested. As a result, certain subjects which are usually considered to be closely connected are dealt with separately in different volumes. Difficulties of this kind, of course, will not seriously diminish the value of the work to chemical engineers, who will find in it an invaluable source of information on their subject. The completion of the six outstanding volumes will be awaited with great interest by all those concerned with chemical engineering or the development of the chemical industry in this country.

Vol. 1. "Chemical Engineering Practice—General"

Vol. 2. "Chemical Engineering Operations and Processes Involving Solid Systems—Part I"

Vol. 3. "Chemical Engineering Operations and Processes Involving Solid Systems—Part II"

Vol. 4. "Chemical Engineering Operations and Processes Involving Fluid Systems—Part I"

Vol. 5. "Chemical Engineering Operations and Processes Involving Fluid Systems—Part II"

$1,130,000 FOR WEATHER MODIFICATION

The National Science Foundation in Washington, D.C., has announced a fiscal 1959 programme of $1,130,000 for research in weather modification. The programme consists of thirteen grants for laboratory research, field experiments, evaluation of present theory and practices, and conferences on modern meteorological methods directed towards weather modification.

The intention is to study more intensively than has been attempted before, the scientific basis of weather modification, through support of competent scientists working in cloud physics and allied fields. Under this programme a full range of laboratory and field experimental work will be carried out using techniques of physics, chemistry, and mathematics, all of which play important roles in meteorological research.

In the laboratory, freezing nuclei particles will be examined with the electron microscope to determine their nature and make-up. Tests will be made to find the most efficient freezing nuclei.

In the field, numerous cloud-seeding experiments, using silver iodide and other cloud-seeding agents, are planned. The purpose is to find out more about how clouds form and grow, about the precipitation mechanism, and about variations in precipitation that may be attributed to cloud-seeding. Other means of modifying clouds and weather will be further studied, including introduction of layers of lamp-black and other heat absorption agents to change artificially the radiation balance of clouds, and inducing local changes in atmospheric electricity with probable resultant changes in cloud droplet growth and precipitation.

Finally, the NSF programme includes study and improvement of the physical and statistical evaluation methods employed in determining the results of any seeding operation. Perhaps the greatest difficulty in this field is to differentiate clearly between man-caused rainfall and the rainfall that would have occurred if man had not intervened.

OIL FROM COAL

In April the Minister of Power appointed a committee to look into the current status of processes for converting coal into oil, gas, and chemicals, and to advise him in what direction, technically and organisationally, future activity in this field should proceed.

The Committee, under the chairmanship of Mr A. H. Wilson, F.R.S., Deputy Chairman and Managing Director in charge of Research and Development for Courtaulds Ltd, is a strong one, and Lord Mills is to be congratulated on getting together a team with wide technical and business experience, which can be expected to give him realistic advice on this important and difficult subject.

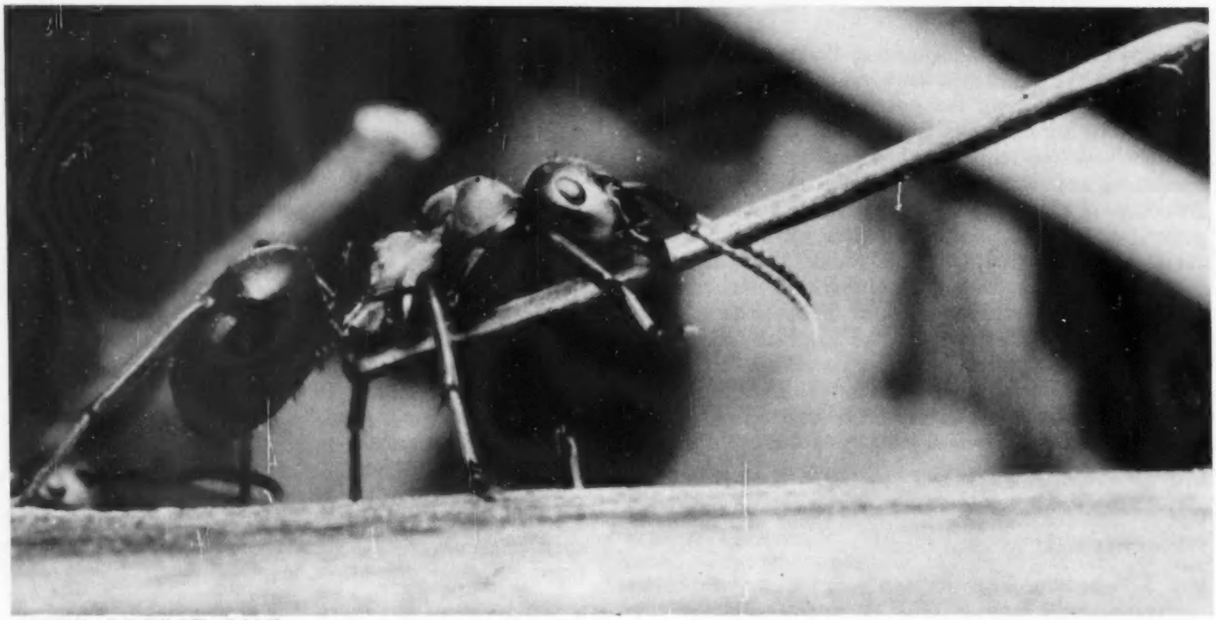
It is not hard to make liquid hydrocarbons, gas, and chemicals from coal; this has been done industrially many times. What is difficult is to make them cheaply. The present margin between the cost of the cheapest coal and the price which the products are likely to command on the market is not large, and development of improved processes is necessary if the cost of conversion is to be brought within this margin. But there are other aspects to the business than the narrowly economic one. Coal is the United Kingdom's only indigenous source of energy, and it is plentiful. A process able to upgrade the poorer qualities of coal, such as may soon be in permanently surplus supply, and convert them into high-grade products, would be a good investment and a valuable balancing factor in the United Kingdom's energy budget. Whilst nuclear energy will take much of the load of the country's increasing energy demands, liquid fuels will continue to dominate the field of automotive and aviation power. Although it is unlikely that Great Britain could ever, by such means, make herself independent of imported oils, an indigenous synthetic oil, gas, and chemical industry could reduce the vulnerability which became so clear at the time of the Suez disturbance.

Against this it can be argued that the United Kingdom does better to use its efforts making goods for export so as to be able to buy cheap foreign oil, than to spend them on mining coal and converting it into oil. The force of this argument depends on the relative costs of the oil from the two alternative sources, and what these will be in the future no one can know.

Oil is not the only product at which the Committee has been asked to look, and a new route to town-gas, if cheap would be welcome to the gas industry. The other products, waxes, and oxygenated compounds, are also in demand.

The prospect that an industry of this sort would give a financial return of the magnitude customarily looked for when private capital is to be invested are not good. For this reason the expenditure needed for development must come from Government sources, and an oil-from-coal project is therefore one well suited to public, as against private, enterprise.

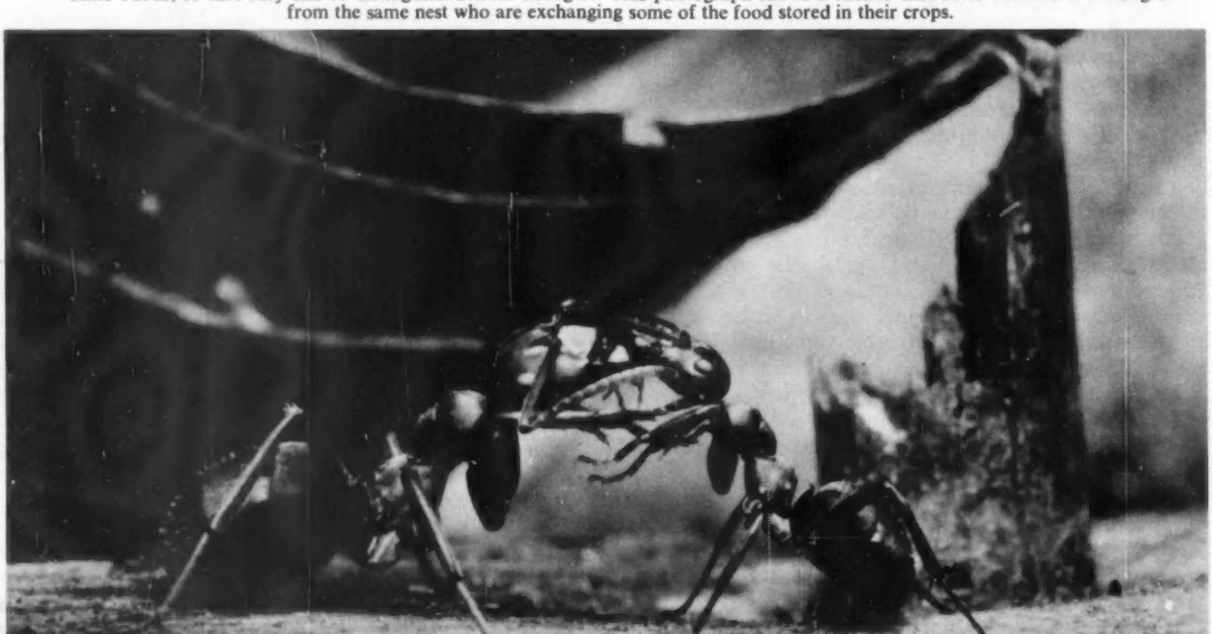
The Committee's report, which is to be presented to Parliament, will be awaited with interest because of the many technical, economic, and even political factors which it must take into account.

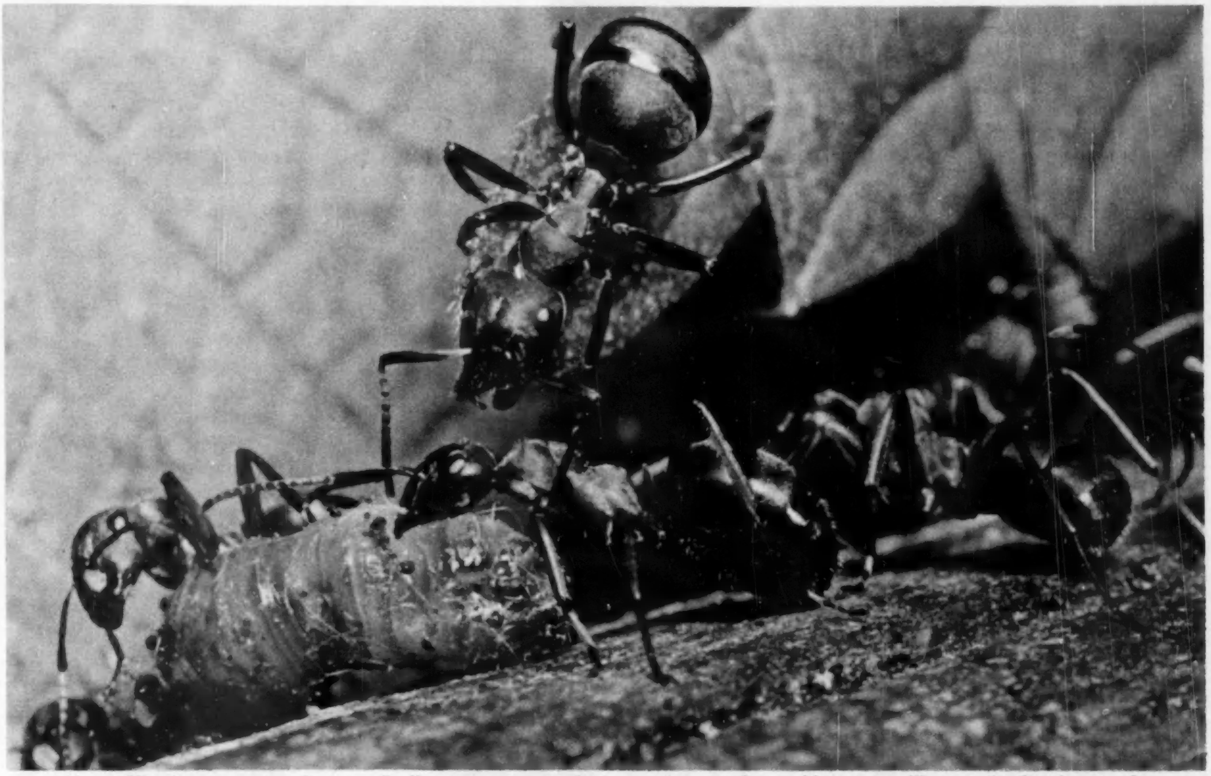


THE FOREST ANT

(*Above*) The wood ant, *Formica rufa*, is perhaps the most generally known species in Britain and on the Continent because of its size, ferocity, and open-air life. In warfare, the ants attack in serried masses and do not hesitate to sacrifice themselves for the common good. The nests usually consist of a large, conical mound of pine needles, twigs, leaves, dry grass, and other vegetable refuse. They are to be seen in shady clearings of woods and forests on acid soils, sometimes on heaths and moors but never far from trees. In the photograph a worker ant is carrying a pine needle, the item most commonly used in nest construction.

(*Below*) The mutual exchange of food material occurs among all social insects. It results in all members of a colony having the same odour, so that they can be distinguished from strangers. This photograph shows a chance encounter between two foragers from the same nest who are exchanging some of the food stored in their crops.

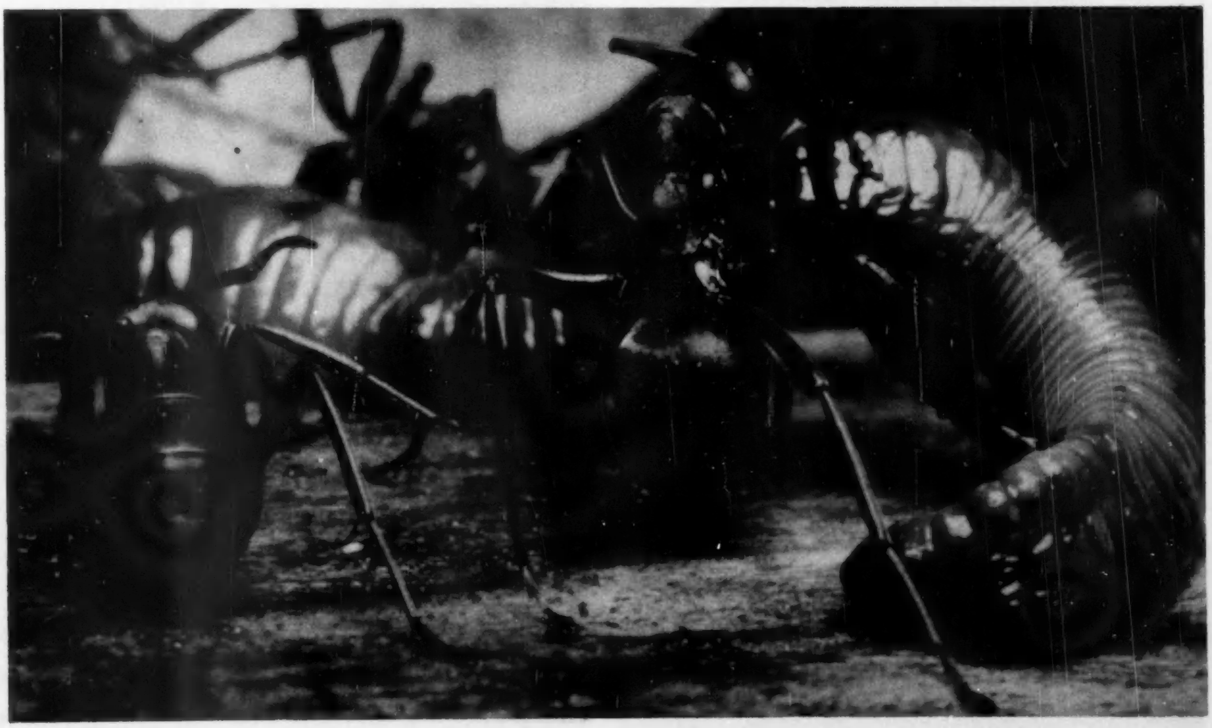




(*Above*) Wood ants are omnivorous, feeding on nectar, seeds, honey-dew, carrion, spiders, caterpillars, and other insects, for which they scour every bush and tree in the neighbourhood. Thus they are of great value in clearing woods and forests of insect pests, and for many years have enjoyed legal protection in Germany.

(*Below*) When the prey is unusually large, several ants will combine to dismember and drag it to the nest. They are very strong and able to lift surprisingly heavy weights in proportion to their size.

(Photographs by Harald Doering, Kirchseeon, Germany)



ISAMBARD KINGDOM BRUNEL (1806–59)

The son of the distinguished engineer, Sir Marc Isambard Brunel, Isambard Kingdom Brunel was born at Portsmouth on April 9, 1806, and attended private schools in this country before spending two years at the Collège Henri Quatre in Paris, an establishment famed for its mathematical teaching. After gaining practical experience at the works of Bryan Donkin, he entered his father's office and took part in the construction of a tunnel under the Thames from Rotherhithe to Wapping. The project was jeopardised by many disasters before the tunnel was finally completed in 1842. As resident engineer, Brunel showed considerable bravery on numerous occasions when lives were endangered or grave material damage threatened.

His first original, independent piece of work was a plan for a suspension bridge across the river Avon at Clifton, submitted in 1829, but rejected. His second design, however, in 1831, was accepted after the eminent mathematicians appointed to examine the entries found his work the only one to be mathematically exact. His achievement was all the more remarkable because the celebrated engineer Thomas Telford was one of the competitors. The bridge was begun in 1836, but owing to lack of funds was not finished till after Brunel's death.

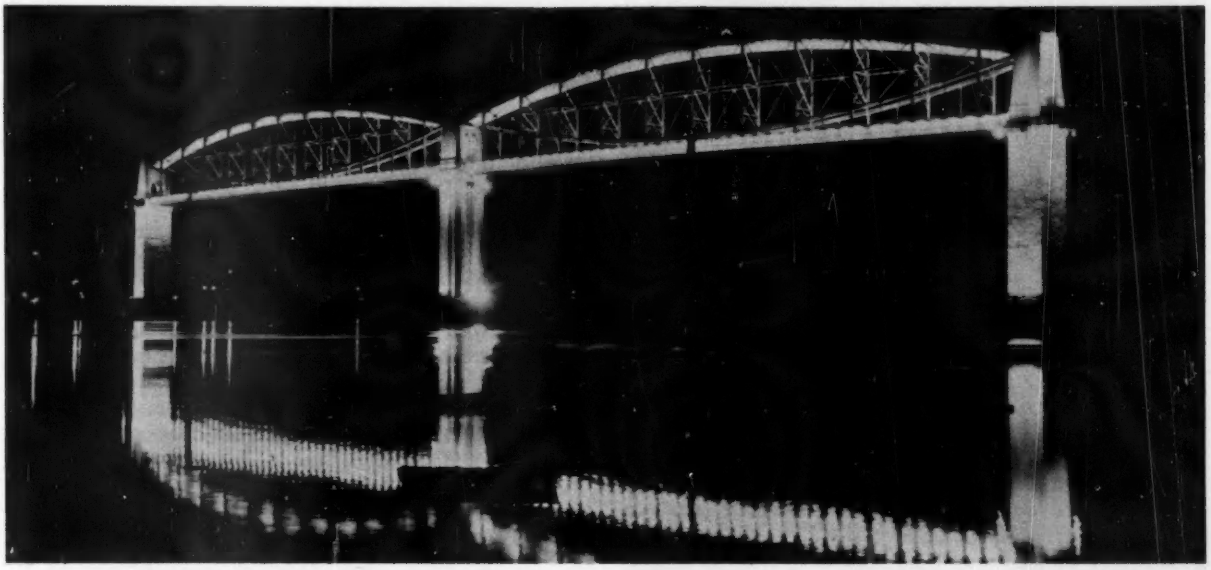
Serving as chief engineer to the Great Western Railway, 1833–46, Brunel became involved in the controversy over the broad gauge—the "battle of the gauges" as it was called. His chief opponent was Robert Stephenson, who advocated the narrow gauge. The way in which Brunel overcame innumerable difficulties during the construction of the Great Western Railway won the admiration of engineers everywhere and resulted in a great demand for his services. It is necessary only to mention the viaducts at Hanwell and Chippenham, the Box Tunnel, and the various bridges of iron and of masonry—all characterised by boldness of design and excellent taste—to realise the magnitude of the task. Perhaps his finest contribution to railway engineering was the Royal Albert Bridge, which carried the Cornwall railway across the Tamar at Saltash, and which was opened in the year of his death.

It is as the designer of the first transatlantic steamer that Brunel is best known to many people. His *Great Western* which measured 236 ft. by 35 ft., and had a displacement of 2300 tons, made her maiden voyage in 1838 in the then phenomenally fast time of fifteen days. In a series of voyages made in *Archimedes*, Brunel experimented with screw propulsion, and on his recommendation the screw propeller was adopted by the Royal Navy in 1845. The first large vessel to be so fitted was the *Great Britain*, an iron ship designed by Brunel, and which made the crossing from Liverpool to New York in 1845. Brunel's crowning effort was the *Great Eastern*, which took over four years to build and was the first vessel in which the double-skin system of construction was employed. Used as a transatlantic passenger ship and as a troop-carrier, she was the largest steamer afloat and proved her strength and excellence of design during arduous years as a cable-carrying vessel. The physical and mental strain involved in building and launching the *Great Eastern* proved too great for Brunel. While watching the engines being tested on September 5, 1859, he had a paralytic seizure and died on September 15.

Though remembered chiefly for his work on railways and steam navigation, Brunel applied his talents to many other problems. He constructed a floating gun-carriage to be used in the attack on Kronstadt in the Russian war of 1854, and superintended the erection of hospital buildings in the Dardanelles in 1855. Possessing the ability to apply his mathematical gifts to engineering problems, and gifted with great mechanical skill, he became one of the foremost engineers of his age. He served on the building committee of the Great Exhibition of 1851, and acted as chairman and reporter of the civil engineering section. A member of many learned societies, he was elected F.R.S. at the early age of twenty-four. He was also a Knight of the Legion of Honour.

Habitually cautious and reserved, careless of contemporary opinion, and self-reliant, Brunel was thought by some to be cold and worldly, but those who came to know him better found him kind and generous. In later years, when he was always overworked, the joyousness which characterised his youth was less apparent. When he died a century ago on September 15, 1859, he was aged fifty-three.

Specially drawn for DISCOVERY by Frank Horrabin.



ROYAL ALBERT BRIDGE, SALTASH
As part of the centenary celebrations, the bridge is being floodlit in colour from May 1 to September 30, 1959. Two hundred and seventy-six floodlighting units are incorporated, including seventy white tungsten lamps, thirty blue-green mercury lamps, and a hundred and seventy-six blue fluorescent tubes. The supporting piers have their faces illuminated in alternately blue-green and white, while the sides of the spans are outlined in blue. The whole 97-kW installation is controlled from the signal-box on the Devon bank.

(Photographs by courtesy of British Railways)

BRAILLE TRANSLATION BY COMPUTER

IBM mathematicians, working in co-operation with the American Printing House for the Blind, have developed a process for translating printed text into Braille by computer. The computer used is an IBM 704, of the type now working with the United Kingdom Atomic Energy Authority and it can convert a 300-page book into Braille in one hour—a job that would take skilled translators more than six days.

A knowledge of Braille by the computer personnel is not necessary. This new technique will make available many school and technical books now rarely produced in Braille, thus enlarging the career possibilities for the blind. To speed this translation, printed texts will be recorded on magnetic tape and distributed to computer installations, where they will be translated and the cost borne by IBM.

Writing Braille requires knowledge of many complicated rules. Symbols often change their meaning in a different context. Braille consists of 63 combinations of six raised dots which represent not only the letters of the alphabet, numerals, and punctuation marks, but also 183 special contractions and abbreviations, as in the case of shorthand.

Texts to be translated by the computer are first transcribed on to punched cards. The cards are then fed directly into the computer, which has had stored in its memory a programme or set of rules for conversion of English into Braille. The IBM 704 executes as many as 600 instructions per word in less than a fortieth part of a second. Contractions and abbreviations are determined by matching the letters involved against an alphabetical table of Braille equivalents.

The translated text emerges from the computer in coded symbols on punched cards, and these, in turn, are fed to the 704's printer unit which reproduces Braille symbols above the English text for editing purposes. After editing, the corrected punched cards are fed into an embossing machine which produces metal plates ready for use in a rotary press.

Dr Joseph Flanagan holding a Braille printing plate which has been produced electronically. This computer transcribes English text into Braille.

THE STORY OF THE THERMOMETER

Dr R. VOLLMANN*

College of Medicine, University of Illinois, U.S.A.

Hippocrates recognised the importance of body temperature to disease. But it was not until the 18th century that the thermometer was used as a diagnostic instrument.

Long before the thermometer was invented, physicians were able to recognise fever in their patients. Hippocrates (*b.* 460 B.C.) felt the temperature of the skin by applying his hand and distinguished between slight fever and burning fever. A number of people are credited with having invented the thermometer: Drebbel, Santorio, Galileo, van Helmont, Fludd, Guericke. The date of Galileo's invention is variously given as 1592–3 and 1611–12; his writings, however, contain but an undated fragment on the thermometer (*Opere*, Ed. naz., Florence, 1890, vol. 8, No. 6, p. 634). It is probable that his notes on thermometry, like some of his other writings, were burned by the Inquisition. According to his last pupil, Vincenzo Viviani, the date of Galileo's invention is the close of 1592. His open air thermoscope measured approximately 50 cm.; it consisted of a glass flask fitted to a tube and warmed by hand; the glass was turned upside down and the open end was dipped in a vessel containing water. When the glass cooled down, the water began to ascend in the tube. The change in volume of air with temperature served to measure degrees of heat and cold.

Cornelis Drebbel of Holland in 1624 constructed an air thermoscope, which had already been anticipated by Ktesibios in the 3rd century B.C.

Independently of Galileo and Drebbel, the Italian physician Santorio Santorio devised a glass thermoscope (*instrumentum temperamentorum*) for "testing the heat of persons in a fever" in about 1614. His instrument also was an open air thermometer which was affected not only by changes in temperature but also by atmospheric pressure.

The famous Magdeburg burgomaster and physicist Otto von Guericke (1602–86) introduced a technically improved form of open air thermometer.

INVENTION OF SEALED THERMOMETER

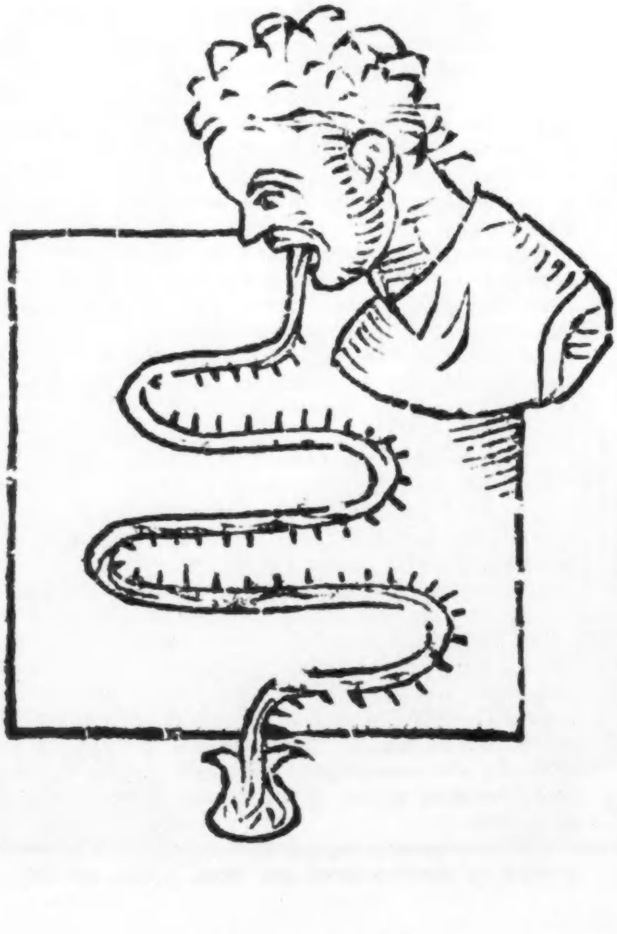
The first description and illustration of such an instrument is found in "Saggi di naturali esperienze fatte nell'Accademia del Cimento" (Florence, 1667), but the name of the inventor is not mentioned. It is interesting to note that the members of the Academy experimented with mercury, which they abandoned because of its poor expansion.

Ferdinand II, Grand Duke of Tuscany, and founder of the Academy, is said to have possessed an alcohol thermometer in 1654, which he used for meteorological observations and for the control of his incubators.

The Florentine thermometers were the first that were independent of atmospheric pressure. They had two "fixed points": the temperature of the snow and the greatest heat of the summer, and the interval between them was divided into equal parts. On November 7, 1646, the Lyons physician B. de Monconys noted in his diary at Florence that he visited Evangelista Torricelli, who showed him a number of thermometers. He describes two types: one with a sealed and one with an open bulb, but he does not mention a sealed Florentine alcohol thermometer. While on a visit to England, he records in London (May 31, 1663): "In the evening it turned very cold, the thermometer fell $6\frac{1}{2}$°." which suggests that he carried a sealed thermometer.

FIG. 1. The *instrumentum temperamentorum* of the Italian doctor Santorio Santorio (1561–1636). The upper part of the tube is filled with air, the lower with water. If the upper part is placed in the mouth, or heated by contact with other parts of the body, the air expands and the water is displaced.

(From a woodcut published in Dr Santorio Santorio's book, "Commentaria in primam Fen primi libri Canonis Avicennae". Venice 1646.)



* Translated and revised by Dr W. R. Bett from the special issue of *CIBA-Zeitschrift* No. 87, entitled "Das Thermometer".

FIG. 2 (*right*). Galileo Galilei (1564–1642), credited with the invention of the thermometer.
(From a sketch by Ottavio Leoni [about 1578–1630] in the Biblioteca Marucelliana, Florence)

FIG. 3 (*centre, right*). Galileo's experiment with a thermometer as shown in Delancé's book, "Traittez des Baromètres, Thermomètres et Notiomètres ou Hygromètres", Amsterdam, 1688. *A*, Thermometer bulb. *BB*, Neck of the thermometer. *C*, Height of the water column (the rest of the neck and the sphere contained air). *D*, Water bowl into which the open end *E* of the neck is immersed.

FIG. 4 (*below*). Galileo's air thermometer. If the glass sphere is heated, the air in it expands and depresses the water column.

FIG. 5 (*bottom, right*). The air thermometer of Cornelis Drebbel. The retort is filled with air and its neck immersed below the surface of the water in the bowl. If the retort is heated the expansion of air is shown by bubbles rising in the water.
(From a drawing in Cornelis Drebbel's book, "Tractatus von Natur der Elementen", Erfurt, 1624.)

FIG. 6 (*left*). Heron's pneumatic experiment sketched by Leonardo da Vinci.

(*Codice F, folio 16 verso; Edizione curata dalla Mostra di Leonardo da Vinci in Milano. Novara, 1940.*)

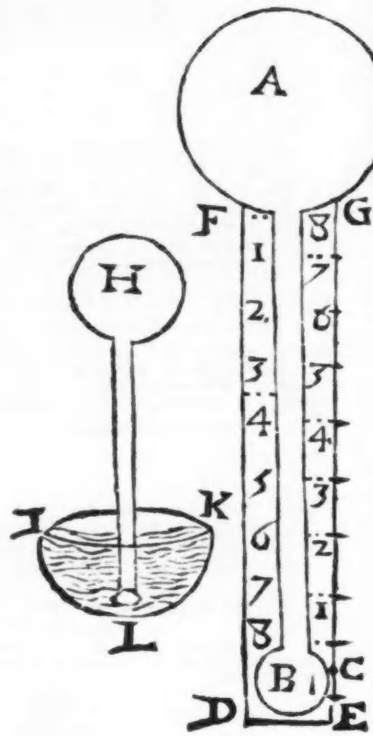


FIG. 7 (*right*). *Thermoscopium vulgare.* Drawing on the left shows Galileo's thermoscope. In the apparatus on the right the expansion of air in sphere (*A*) is indicated by a drop of liquid in the glass column (the drop is not shown in the drawing). The sphere (*B*) is perforated to compensate for increased pressure (the perforation is not shown either in the drawing).

(*From "Cogitata physico-mathematica", by Marin Mersenne. Paris, 1644.*)

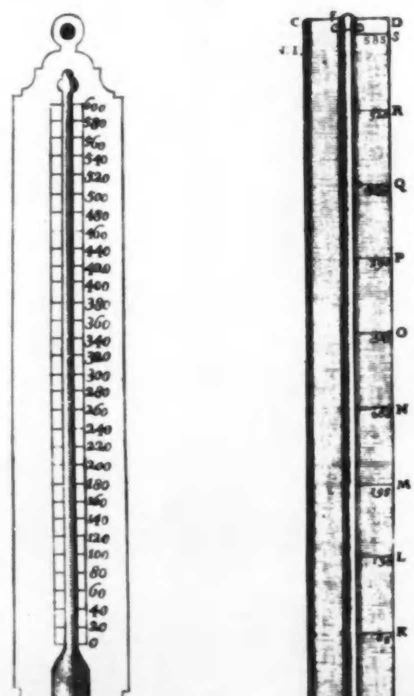


FIG. 8 (*bottom, right*). (*Left*) The Accademia del Cimento's mercury thermometer which has a scale graduated into 600 degrees.

(*From "Tentamina experimentorum naturalium captorum in Accademia del Cimento", by P. van Musschenbroek. Vienna, 1756.*)

(*Right*) Another mercury thermometer also graduated into 600 degrees.

(*From "Elementa Chemiae", by H. Boerhaave. Leiden, 1732.*)

DEVISING A UNIVERSAL SCALE

In his "New Experiments and Observations Touching Cold" (London, 1665), Robert Boyle stressed the need for a standard that would enable temperatures to be compared. He criticised the choice of a freezing-point as a thermometric fixed point, for his observations with various fluids had shown him that these did not always freeze at the same temperature. Using oil of aniseed for obtaining a fixed point, which he placed round the bulb of an alcohol thermometer, he marked the height of the alcohol when the oil began to curdle. Under his direction, Robert Hooke, Curator of Experiments to the Royal Society, constructed the first hermetically sealed alcohol thermometer in England, probably before 1663. One of these standard thermometers was sent to Christiaan Huygens, who modified it, being the first to use the freezing- and boiling-points of water as thermometric fixed points.

In 1724 Fahrenheit discovered the dependence of the boiling-point on atmospheric pressure. The physicist Jan Hendrik van Swinden in 1778 listed seventy-one different thermometers constructed by more than sixty inventors.

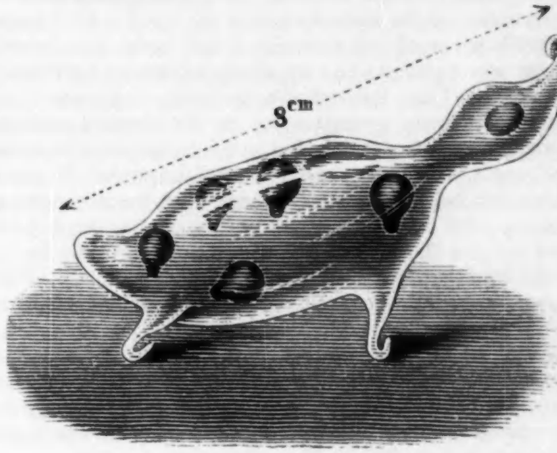


FIG. 9 (*above*). A thermoscope shaped like a frog which works on the principle of the famous Cartesian diver. This instrument was probably invented by the Archduke Ferdinand II of Tuscany.

(This model was shown at the International Exhibition of Scientific Instruments, London, 1876.)

FIG. 10 (*left*). The famous Mayor of Magdeburg, Otto von Guericke (1602–86), who constructed an improved type of air thermometer, shown on the cover of this issue.

(From a sketch in "Experimenta nova Magdeburgica", Amsterdam, 1672.)

FIG. 11 (*below, left*). Hermann Boerhaave (1668–1738), who was one of the first to advise his students to use a thermometer.

(From a portrait by Fr. Nicolai, printed in the German edition of Boerhaave's "Elementa Chemiae", Berlin, 1762.)

FAHRENHEIT, REAUMUR AND CELSIUS

Gabriel Daniel Fahrenheit (1686–1736) was the son of a prosperous Danzig merchant. After serving as an apprentice in a business house at Amsterdam (in his spare time he constructed meteorological instruments) he studied science and, probably before 1709, devised a remarkably accurate alcohol thermometer which rapidly became famous throughout the whole of northern Europe. Its description was published in the *Philosophical Transactions* of the Royal Society for 1724. It had three fixed points: the temperature of a cold mixture, the temperature of ice water, and the mouth or axillary temperature of a healthy human being. Originally, Fahrenheit divided the space between fixed points 1 and 3 into 180 equal parts; halving this, he found a geometric zero which he called "tempéré" and above which he counted 90° heat and below 90° cold. The thermometers constructed by him were of two kinds: one filled with alcohol, the other with mercury.

René-Antoine Ferchault de Réaumur (1683–1757) discovered that alcohol possessed greater expansibility than water. Since the beginning of solidification of water is a

fixed, constant point, he stated, the degree of expansion or contraction of the alcohol through the ice is a fixed point, suitable for nearly all countries in the world. His thermometer was a plump and very slowly registering instrument. It differed from Fahrenheit's in having only one fixed point—the zero corresponding to the freezing-point of water. The level of the alcohol at this temperature he called 100 parts. In boiling water, alcohol expanded 80 parts. Réaumur then divided the distance from freezing-point to boiling-point into 80 equal degrees. Joseph Nicolas de Lisle and Jacques Barthélemy Micheli du Crest were the first to point out that Réaumur's thermometer recorded not the temperature of boiling water but the temperature of boiling alcohol. To remedy this defect, du Crest constructed an alcohol over-pressure thermometer. Réaumur was not a physicist but a lawyer and entomologist, which explains his ignorance of important publications concerning the development of the thermometer. He refers nowhere to the Fahrenheit scale. The boiling-point selected by him showed deviations of 25 to 35 degrees. Jean André Deluc (1727–1817) drew attention to the fact that in Réaumur's instrument neither freezing-point nor boiling-point correspond to the degree specified by Réaumur. Using mercury, Deluc divided the distance between the temperatures of melting ice and boiling water at a given barometric pressure into 80 parts.

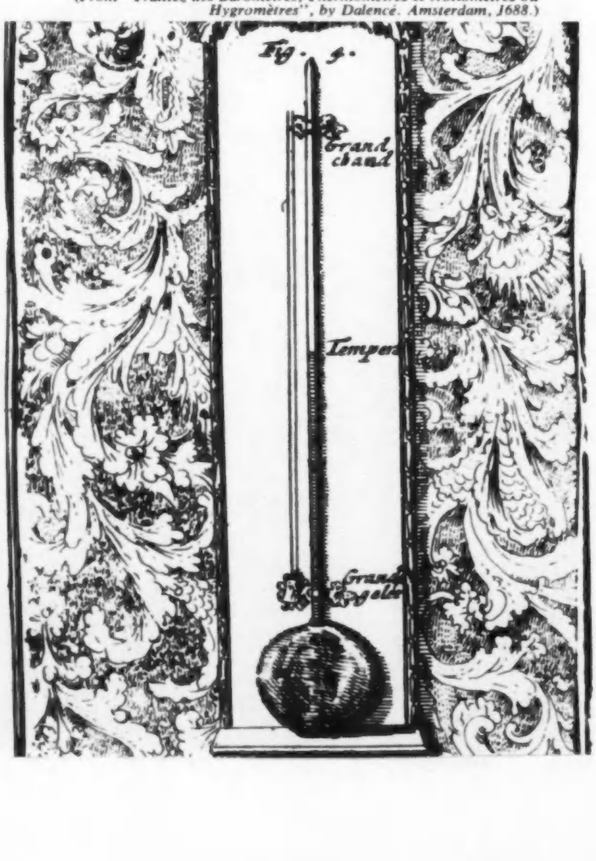
The Swedish astronomer Anders Celsius (1701–44), in the course of meteorological observations, noted how defective were the thermometers employed in the Uppsala Observatory, and in 1742 suggested a scale having zero at the boiling-point of water and the hundredth degree mark at the temperature of melting ice. The Celsius or Centigrade scale was inverted by a Lyons physician, Jean Pierre Christin.

FIG. 12. The Swedish astronomer Anders Celsius (1701–44). He was the first person to use a temperature scale with a hundred divisions. 0° was the boiling-point and 100° the freezing-point of water. This scale was reversed by J. P. Christin, a Lyons physician.

(The above etching is in the possession of the Federal Astronomical Observatory in Zurich.)

FIG. 13. One of the first thermometers with a closed glass tube. It has no complete scale and is roughly divided into three parts.

(From "Traittez des Baromètres, Thermomètres et Notiomètres ou Hygromètres", by Dalencé. Amsterdam, 1688.)



EXPERIMENTS BY MEDICAL MEN

In order to determine the source of animal heat, the mathematician and physiologist Giovanni Alfonso Borelli (1608–79), member of the Accademia del Cimento, measured the temperature in animals with a Florentine thermometer. He showed that respiration did not serve to cool "the flame or heat of the heart" and to provide it with fresh air. His discovery that the heart and the intestines had the same temperature suggested to him that the heart was not the principal source of animal heat and did not require cooling or aeration because of its supposed heat. (*De motu animalium*, 1685.)

More than seventy years later the English theologian and naturalist Stephen Hales (1677–1761) attempted to calculate the respiratory heat loss in man by comparing the temperature of the inspired air with that of the expired air and of the blood. He also determined the temperature gradients between skin, axilla, mouth, and urine. The observation of the constancy of body temperature in man and in animals provoked a prolonged discussion as to whether environmental temperature was always lower than body temperature and which was the maximum temperature compatible with life. Experiments were performed on human beings and on animals, which proved that even extreme environmental temperatures had little influence on body temperature.

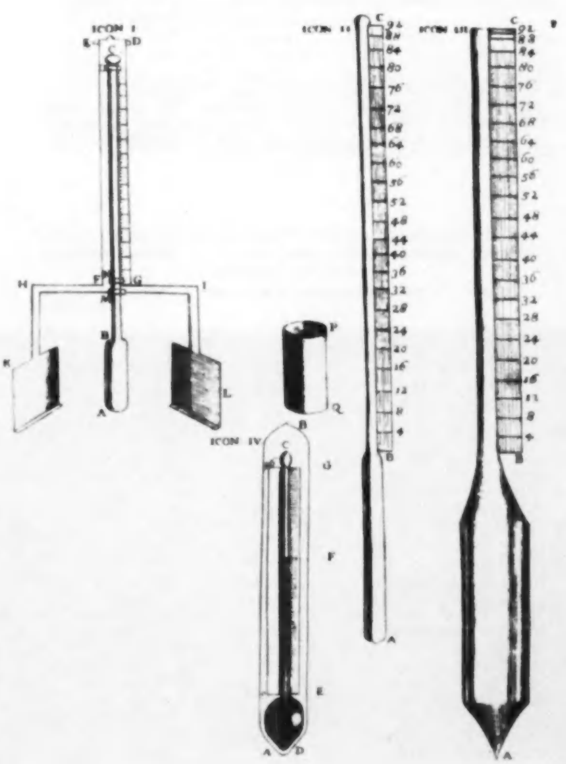
In 1775 the surgeon John Hunter (1728–93) reported to

FIG. 14. The French zoologist René-Antoine Ferchault de Réaumur (1683–1757), who used a thermometer where the freezing-point of water was 0° and the boiling-point 80°.

(The above etching is in the possession of the Federal Astronomical Observatory in Zurich.)

FIG. 15. Four early thermometers with completely enclosed glass containers. *Icon I:* A thermometer mounted on a wooden support with a small container (*PQ*) for the liquid, the temperature of which was to be measured. *Icon II:* Fahrenheit's first thermometer which used coloured alcohol. *Icon III:* Fahrenheit's second thermometer which used mercury. *Icon IV:* Fahrenheit's third thermometer which could be used with either mercury or alcohol. It could be placed under the arm or in the mouth of a patient to take his temperature.

(From "Elementa Chemiae", by H. Boerhaave. Leiden, 1732.)



the Royal Society the results of his investigations with Blagden, Fordyce, and Jenner on the constancy of body heat and on the temperature of hibernating animals. Hunter produced artificial inflammation in a hydrocele and noted that the temperature of locally inflamed parts of the body did not exceed that of the body. He took his own temperature by mouth, rectum, and urethra, and his finding that the farther the thermometer was introduced into the urethra, the higher was the temperature recorded, furnished the first data on temperature gradients in man.

BEGINNINGS OF CLINICAL THERMOMETRY

The great Hermann Boerhaave wrote in 1709 ("Aphorismi de cognoscendis et curandis morbis in usum doctrinae domesticae"): "Fever is recognised externally by the thermoscope and by touch, and internally by the red colour of the urine." This aphorism suggests that at that time raised temperature was regarded as a characteristic sign of fever and that with the introduction of proper clinical teaching in the Leyden hospital the daily temperature recording of all patients began. Boerhaave was a friend of the "talented mechanic" Fahrenheit, who constructed for him both alcohol and mercury thermometers. Boerhaave believed that in shivering fits the skin temperature was reduced—an error that was responsible for prolonged arguments.

In 1745 Boerhaave's favourite pupil, Gerard van Swieten, was called to Vienna as personal physician to the Empress Maria Theresa and chief of the medical faculty. He reformed the medical teaching in the university according to Leyden principles. Like his teacher, he looked upon the pulse as the most certain guide to fever and attempted to establish a numerical relationship between raised temperature and pulse frequency. While he admitted the usefulness of gauging body temperature by applying the hand to the skin, he stated that exact measurement of fever was possible only with a thermometer, the available instruments being most reliable and portable, and named after their inventor, Fahrenheit. The best, in his opinion, were the mercury thermometers.

In 1754 another pupil of Boerhaave's, Anton de Haen, went to Vienna to become the first professor of medicine at the medical clinic. He laid down categorically that the thermometer was the only reliable measure of temperature and undertook a large number of observations on himself and on others. Measuring the body heat of the new-born during the first ten days, he found little difference between it and that of adults, and he failed to note any characteristic temperature difference between men and women. He observed that temperature could rise after death, and that a paralysed limb was cooler than a normal limb. For the first time in the Vienna Clinic the thermometer was used as a diagnostic instrument.

In England the thermometer was used extensively by James Currie (1756–1805) to control the effect of his cold-water treatment of febrile diseases, especially typhoid. "Medical Reports on the Effects of Water, Cold and Warm, as a Remedy in Fever and Febrile Diseases" (1797) has been described as the first large-scale attempt at consistent experimental treatment of fever. Currie worked with mercury thermometers made by Jesse Ramsden according to Hunter's instructions. These were not self-registering,

and the temperature had to be read with the instrument *in situ*. As many of Currie's patients were suffering from contagious diseases, he modified Hunter's thermometer by bending the stem at an angle, so that it could be read by the observer standing behind the patient, while the instrument was in his mouth or axilla, thus avoiding his breath. Currie believed that respiration was the chief source of body heat. When his son contracted scarlet fever in 1801 and was dangerously ill, his father locked himself in a bathroom with the patient and, the patient's temperature remaining constant at 109°F, fourteen times in thirty-two hours poured water 40°–60°F over him. On the morning of the third day the boy had recovered.

The French physician Paul Joseph Lorain (1827–75), in his book, "De la température du corps humain" (1877), definitely established the place of thermometry as a daily method of clinical investigation, and Pierre Adolphe Piorry (1794–1879) carried a thermometer in his stethoscope. Jean Baptiste Bouillaud (1796–1881) popularised the use of the thermometer in the medical clinic of the Hôpital de la Charité. Thermometry was introduced in the German clinics by Ludwig Traube (1818–76), F. W. F. von Baerensprung (1822–64), Carl August Wunderlich (1815–77), Carl von Liebermeister (1833–1901), Theodor Jürgensen (1840–1907), and Theodor Billroth (1829–94).

In this article scant justice is done to Wunderlich, professor of medicine at Leipzig, whose book, "Das Verhalten der Eigenwärme in Krankheiten" (1868), has been described by Garrison as "the very foundation of our present clinical thermometry. . . . He found fever a disease and left it a symptom."

In spite of all the advances in pathological-anatomical bacteriological, serological, and roentgenological technique, daily recording of temperature has retained its incomparable value as a continuously registering procedure for mediating the changing reactions of the diseased organism.

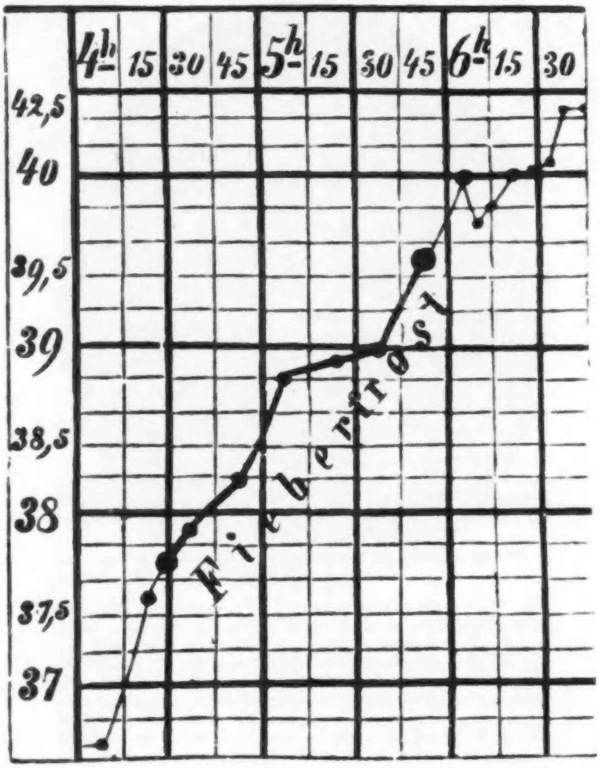


FIG. 16 (*above*). An early temperature record of a patient's fever made by C. A. Wunderlich.

(*From "Das Verhalten der Eigenwärme in Krankheiten", by C. A. Wunderlich. Leipzig, 1870.*)

FIG. 17 (*bottom, left*). One of the first graphical representations of temperature changes. The graph was recorded by Ole Reomer in Copenhagen and shows air temperatures from December 26, 1708, to January 9, 1709.

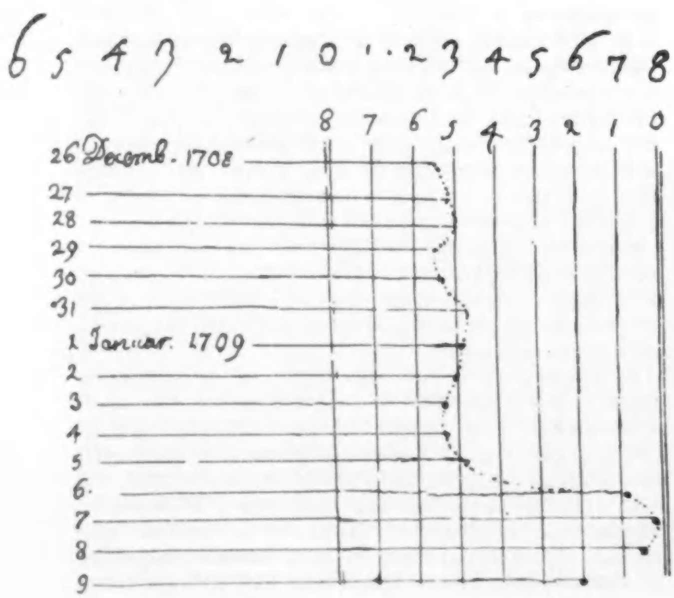
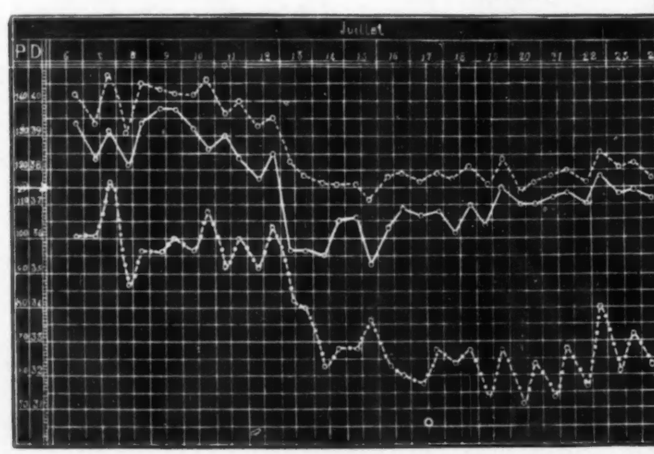


FIG. 18 (*below*). A record of oral and rectal temperature-graphs together with pulse rate of a patient suffering from pneumonia.

(*From "De la Temperature du corps humain . . .", by P. J. Lorain. Paris, 1877.*)



THE PROPER STUDY OF MANKIND IS MAN

SIR JAMES GRAY, C.B.E., M.C., F.R.S.

An extract from the Presidential Address at the York meeting of the British Association for the Advancement of Science

James Gray was born in 1891, educated at the Merchant Taylors' School and went up as a scholar to King's College, Cambridge, of which he was elected a Fellow in 1914. His spell of research at the marine stations at Plymouth and Naples threw light on the physical nature of the cell membrane as a boundary between living protoplasm and the environment, and the subject of his first important paper to the Royal Society, presented in 1914, was the electrical conductivity of the eggs of sea urchins. His keen interest in the development of British marine biology dates from this time, and in 1945 he was chosen by the Marine Biological Association as its president, an office which he held for ten years. Today, he is also Chairman of the Fishery Advisory Committee and a Development Commissioner.

After the 1914–18 war, in which he served in the Queen's Royal West Surrey Regiment and was awarded the Military Cross, his main study was animal movement. Using instruments borrowed from the physicist and physical chemist, his investigations were active and experimental and, breaking away from the shadow of Darwin under which many of his senior colleagues still laboured, he played the leading part during years of controversy in establishing this new vision of what zoology is about. Now Professor of Zoology at Cambridge (since 1937), he is recognised as one of the most distinguished experimental zoologists in the world.

His research has never strayed far from his chosen field, but his outside interests are wide. He is a Trustee of the British Museum and was on the Agricultural Research Council during the war. To all of these, as to his office as President of the British Association, he brings his humane biologist's viewpoint.

(Photograph by Ramsey Muspratt, Cambridge)

In the public mind, science is largely associated with the study of physical systems and practical problems. Within this range, scientists are not concerned with moral principles nor are they directly responsible for the social repercussions of their discoveries. But it is impossible to be a scientist without being a human being and recognise that life depends much more on moral principles than on scientific knowledge. So far as science is mainly concerned with our material environment, it tends to isolate itself from the main factors which determine human behaviour. So far as the humanities are mainly concerned with Man's reactions to past environments, we cannot be quite sure how far their judgments are relevant to modern life. Such limitations will not be overcome by keeping our own particular type of knowledge in a watertight compartment, but by trying to visualise it as part of a wider picture; the sciences and humanities should seek common ground. Hence the title of my address. Perhaps rashly, I am trying to look at Man from a biological point of view and to suggest how the picture might—here and there—merge into a wider background. But before doing so I would like to touch on two quite general topics.

The Fear of Science and its Cultural Significance

Firstly, one of the most important social aspects of modern science is its repercussion on international relationships. Here there will always be potential danger and waste of human effort until individual nations are prepared to think in terms of the welfare of humanity as a whole. Scientists must approach this problem as they would any other in the laboratory or workshop by subjecting it to dispassionate analysis, but we shall not make much impression on public opinion so long as men's minds are biased by fear and suspicion; frightened or angry men, like frightened or angry animals, cannot be trusted to react wisely. There is, however, not the slightest doubt that the discoveries of physics *have* frightened mankind and that there are far too many intelligent people looking askance at science and wondering where it is leading. In presenting science to the public

our primary objective should be to depict Man's position in the world of Nature as a source—not of fear or doubt, but of courage and inspiration.

Our second objective should be to demonstrate the place of science in a general philosophy of life. To be of real value, such a philosophy must rest on knowledge and experience which is acceptable over a very wide range of local environments and national interests and it must, at the same time, be closely concerned with problems of everyday life. In these respects science is unique. Not only do scientists of all nations co-operate in solving Nature's jig-saw puzzles, but as Prof. A. V. Hill said at Belfast in 1952: "The fundamental principle of scientific work is the unbending integrity of thought, following the evidence of fact wherever it may lead within the limits of experimental error and honest mistake." This attitude of mind is not peculiar to scientists; it is common to all who have a respect for the truth. But in the fields of law, language, history, literature, and, above all, politics, our general outlook and our individual range of knowledge depend to a very dangerous extent on local environment and national tradition. By freedom from such limitations science provides ground—perhaps the most solid ground—on which to base a wider range of co-operative effort.

We have to recognise, however, that the factors which control human behaviour are not, at present, amenable to the laws of physics and chemistry; we are forced to apply the less precise, but not necessarily less important, principles to be derived from the world of living organisms. The challenge is, therefore, to the biological sciences, especially those which deal, at the borderline of sociology, with the behaviour of organisms and their relationship to their environment. Can they yield broad principles which are applicable to Man, or must scientists be content to see the law of the jungle take its course except in so far as it can be restrained by political effort? The answer to such questions may well decide how far science can claim to be of direct cultural significance.

Man as a Biological Entity

To visualise Man's position in the animal world, it may be convenient to define his main diagnostic characters. He is a highly gregarious bipedal mammal with unspecialised limbs but a very large brain. He is the only animal which has developed the symbolisms of speech and writing, and he may well be the only animal capable of rational thought. He is, therefore, the only organism which can hand on patterns of acquired learning from one generation to another. To these advantages he owes his dominant position in the world today. They have enabled him to exploit his environment and increase his numbers and range of distribution far more quickly and far more extensively than any animal of comparable size. He has eliminated some of his competitors and exploited others for his own use, but the time has now come when different races of men are competing with each other within the closed arena of a limited environment and it is not easy to see where it will end. There is nothing equivalent to this in the inanimate world; but when a biologist looks at the general trend of events, he is inclined to say, "Where have I seen something like this before, what is it due to, and how does it *usually* end?"

One of the first attempts to subject human populations to biological analysis was made by Malthus in 1789, when he forecast the fate of a nation whose rate of increase was greater than that of the resources of its environment. Malthus did not say that war, pestilence, and famine were inevitable; he said that they were inevitable unless people, by voluntary control, reduced their rate of reproduction. Western Europe and America have followed his advice; but, as stressed by Prof. Blackett in Dublin in 1957, the density of population in other parts of the world is far higher than can be adequately sustained by the environment. We can, of course, shrug our biological shoulders and say that different races of men live in different environments and are, therefore, subjected to different intensities of struggle, and it would be nice if we could be quite certain that it is always the fittest which survive. We cannot salve our consciences quite so easily nor will we escape for very long from environmental pressure. Our own population may remain relatively stable but our environment expands with almost every new major scientific discovery and the greater the overlap of the environments of different nations, the fiercer is the competition. The result is substantially the same as that of an expanding animal population within a limited environment. These problems lie within the field of economics, but they are fundamentally similar to those which arise in animal ecology; it seems just as unrealistic to regard one race of Man as an isolated unit as to study the population of one member of a biological food-chain without reference to those of all the others. The writing on the wall is tolerably clear; if Man behaves like an animal and allows his population to increase whilst each nation steadily increases the complexity and range of its environment, Nature will take her course and the law of the jungle will prevail. See pp. 374 and 375.

Men and Ants as Social Animals

To see the law of the jungle in action, it is useful to remember that Nature has made, not one, but two great experiments in the design of social animals. The first was carried out in Mesozoic times when Man's mammalian ancestors were beginning to emerge from reptiles. The results of this experiment are represented today by the social insects—notably the ants. There are a very large number of different species of ants none of which interbreed; among them is found a range of complexity of social behaviour which is not only unique in the animal kingdom but which forms a very remarkable parallel to different races of human beings. At one extreme are species forming small communities, restricted to localised or specialised environments and exhibiting relatively little sub-division of labour between individuals. At the other extreme are large and often aggressive communities with marked differentiation of structure between different grades of individuals; populations of this type display high levels of co-operative effort involving, in some cases, the rudiments of agriculture and husbandry. In all cases, however, ant societies are organised on a straightforward totalitarian basis, the contribution made by each individual towards the welfare of the community is determined from the time of birth and depends very little on experience gained in later life; each grade of individual is structurally adapted for predetermined tasks.

But it is not only in respect to individual relationships that the study of ants is relevant to Man. Ants are the only organisms which—apart from Man—indulge in organised warfare, raiding the nests of other species and carrying off the young. But perhaps the most striking facts relate to species which have changed their habits and distribution within recent times. For example, an instance of territorial expansion and global warfare is known to have occurred in the last 150 years.* Early in the 19th century an Eastern species (*Pheidola megacephala*), having spread rapidly over North Africa and South Europe, managed to reach the islands of Madeira and Bermuda. In both places it exterminated the smaller native races. Meanwhile, a similar policy of territorial expansion had been carried out by another species (*Iridomyrmex humilis*) from the Argentine which, having landed at New Orleans, very rapidly overran the southern United States; in due course, it too reached Bermuda, where it proceeded to eliminate the earlier invader. In the world of ants there is no place for small, peaceful communities unless they can

* Haskins, C. P. (1945). "Of Ants and Men".

isolate themselves effectively from larger and more powerful neighbours, nor does there seem any lasting peace between large, aggressive communities. This is the law of the jungle.

Nature's Experimental Subject: Man

Having designed the ants, Nature waited for about 150 million years before embarking on her second or human experiment. She waited, in fact, until it could be carried out with a species in which an individual's contribution to society was no longer based on inherited structural characters but on the power of intercommunication with other individuals; in other words, until Man's brain had reached a level of development which enabled him to control his environment, and to deal rationally with the sub-division of labour between individuals and with the distribution of natural resources between different groups of individuals. At the same time she arranged that such groups should not be physiologically isolated from each other. Different races of men can interbreed or they can, if they wish, come to mutual agreement about the distribution of world resources between different nations. The first policy would seem to lead to a world state with uniformity of social pattern and material interests; the second policy involves territorial limitations and economic agreements. Both, as we know only too well, involve great practical difficulties. All the same, men really ought to be able to do something better than ants. Perhaps the most striking difference between the social habits of Man and those of animals is the existence of a hierarchy or grading within human society. Only in a very few cases does this appear to exist within the animal kingdom. The nearest approach seems to occur in birds; a flock of jackdaws feeding in a restricted area resolves itself into a well-marked order of feeding priority. Lorentz has recently reported that if a high-ranking male decides to mate with a low-ranking female, the latter rises in social status and feeds with her husband; all this sounds reasonably familiar to human ears.

This is perhaps as far as a zoologist ought to go in trying to view Mankind through biological spectacles. But one does not need to be a professional biologist to appreciate that the range of change in the pattern of human behaviour and in the nature of our environment has, during the past five thousand years, been incomparably greater than those of any other organism at any period of its history; our clothes, houses, habits, and social organisation change with successive generations. In fact, if one were forced to select the organism which best displays the phenomenon of gradual but persistent evolutionary change one would undoubtedly choose Man. I have tried to show that the broad principles which relate the size of human populations to the resources of their environments are fundamentally similar to those which apply to animals. On the other hand, Man is, as I have said, unique in that he is, or can be, the master and not the slave of his environment, and the story of his evolution can therefore be told in terms of social and economic history.

A new and very important integrating factor in the evolution of human society seems to have come into action when natural phenomena became linked with supernatural concepts—fear of isolation or reprisals from fellow-men being reinforced by fear of a superhuman agency and a sense of greater security inspired by reliance on supernatural support. Such beliefs had no material basis, but they would be the cement which held society together and, as such, be of immense survival value. But it is difficult to avoid the conclusion that such beliefs, like scientific theories, must undergo change as Man's knowledge increases and his environment alters. From this point of view, it is not easy to regard any one belief as an expression of absolute and unchanging truth. It may be argued that such things lie outside the orbit of the British Association, but if science is to be of direct cultural significance it cannot shut itself off from one of the main factors which has influenced men's attitude to social problems.

Scientific Education as the Solution

But it is easy to talk and to criticise; it is much harder to plan for action. As far as science is concerned the British Association might approach the problem of general education in the three familiar stages of research, development, and production. The first step would involve an assessment of the evidence; if the Association's judgment were given in favour of a wider, and perhaps more biological outlook on education it should do all it can to see that it is put into practice on a limited front and, in the light of experience, allowed to spread gradually into full-scale production. All this would involve very far-reaching reorganisation of schools and universities. But the University College of North Staffordshire is leading the way by insisting that all students should, during their first year, survey the whole field of knowledge as a coherent picture before proceeding in three subsequent years to specialised training. This is, in my opinion, one of the most important and courageous educational experiments in our times, for, if it succeeds, a great number of our major difficulties will be resolved.

On the other hand, if "general education" is condemned as "a smattering of everything and a knowledge of nothing" and if the concept of a central theme round which all parts of a syllabus would revolve be found to be illusory, it is high time we stopped talking about them. We would have to revise our ideas about the broad cultural value of science but leave ourselves free to concentrate on widening the interests of scientists during or after their technical training. Much can be done by relatively formal teaching, but—if I may judge from personal experience—more depends on the extent to which students are given the time and opportunity to educate themselves by contact with young men and women with entirely different interests and outlook from themselves. This is the great strength of the older residential universities; but, here again, they may have much to learn from North Stafford.

But the older we get, the less inclined we are to go back to school. If we want every member of the population to keep in touch with what is going on in the scientific world and to realise its impact on their lives, we must rely on the Press and on the broadcasting authorities. Neither of these are primarily educational media; in both cases the main objective is to put science across in a form that readers and listeners find interesting. The educational value of a popular article or a broadcast can, perhaps, be judged by the extent to which it arouses a desire to know more and leaves the reader or listener with a feeling that this can be satisfied, at least to some extent, by personal effort. In respect to music, the BBC has been outstandingly successful; other fields of broadcasting may be less amenable, and it is not altogether easy to know how far an increase in factual knowledge concerning the number of isolated fields of science enables listeners to appreciate the broad social and international implications of science as a whole. But these are problems for experts.

But when all is said and done, science can only play its full part in furthering the welfare of Mankind if it is used at a very early stage of education, as a means of encouraging a dispassionate but optimistic attitude towards all aspects of human affairs. To move from national traditions and aspirations to others based on international welfare may prove less painful if we are prepared to look on Man and all his problems as a phase in the evolution of the Universe, and if we have the courage to believe and to teach that he can, by means of his intellect, control and direct his own evolution and destiny.

A PUZZLE COMPUTER

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A computer need not be the complicated electronic device which is usually imagined. It can be simple enough for anyone to make at home.

There is widespread interest in computers, and modern machines are planned not only to undertake numerical calculations but to perform logical tasks as well. Punched cards have been used to sort information for many decades, but their possibilities are still little appreciated by laymen. Using them, it is possible to make a simple "logical computer", a scientific toy which illustrates the essential principles underlying bigger machines, and which will solve automatically many types of inferential puzzle. One or two basic patterns of punching suffice for many different puzzles.

The cards should have a row of holes punched along the top edge; where necessary the holes are cut away to leave slots. A hole means "Yes" and a slot means "No". If the cards are stabbed through any particular hole, when the needle is lifted the cards with holes will be raised up, and those with slots will be left behind. Two operations are basic, corresponding to the logical connectives "and" and "or". It is immediately apparent that by stabbing two holes "in series" one can lift only the cards having holes in both places (*and*), and by stabbing holes "in parallel" one can lift cards having a hole in one place *or* the other. All more complicated logical operations are constructed from these two, and from the operation "not", whose interpretation in terms of cards is again obvious.

2^n–PUNCHING

Punched cards, used in this way, are an example of a mathematical system known as a distributive lattice, and their structural relations are described by Boole algebra.

A pattern which will solve many problems is 2^n-punching. Effectively the holes and slots are used as digits in the binary scale, and the 2^n combinations which can be made up using n positions on the card are punched. If $n=6$ we need 64 cards, and this is a reasonably sized pack for puzzle solving.

This punching will handle such problems as:

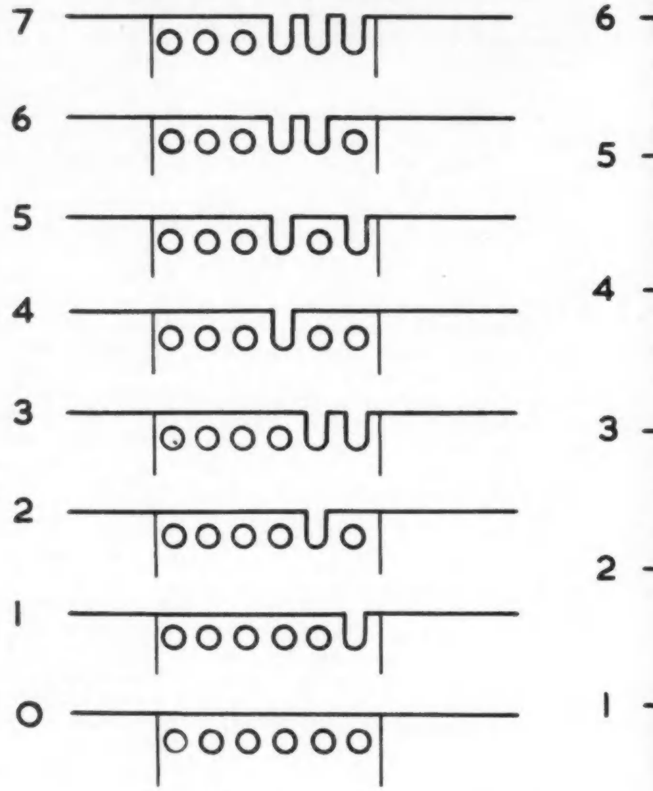
A delegation of three men has to be chosen from among six candidates.

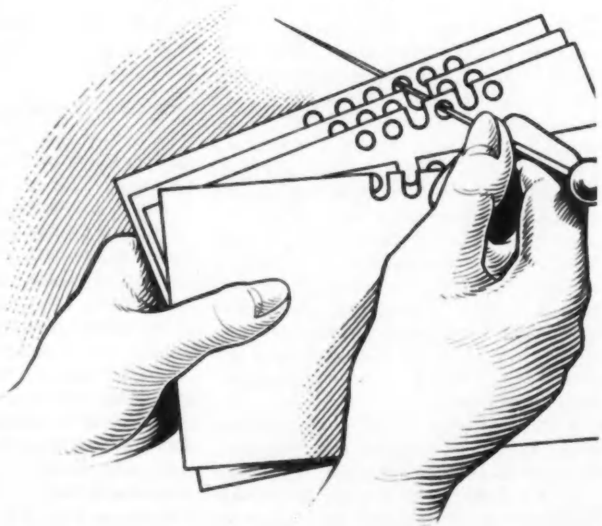
> Abbott won't serve unless Dickson does,
> Brown won't serve with Dickson unless Cook serves too,
> Cook won't serve without Finch,
> Dickson will serve with anybody,
> Ellis won't serve with Cook or Abbott,
> Finch won't serve unless Abbott or Brown serves, and won't serve with Dickson unless Ellis serves too.

In how many ways may the delegation be formed?

We can use our pack of 2^6 cards, using a hole to denote that the corresponding person is on the delegation, and a slot to denote that he is not.

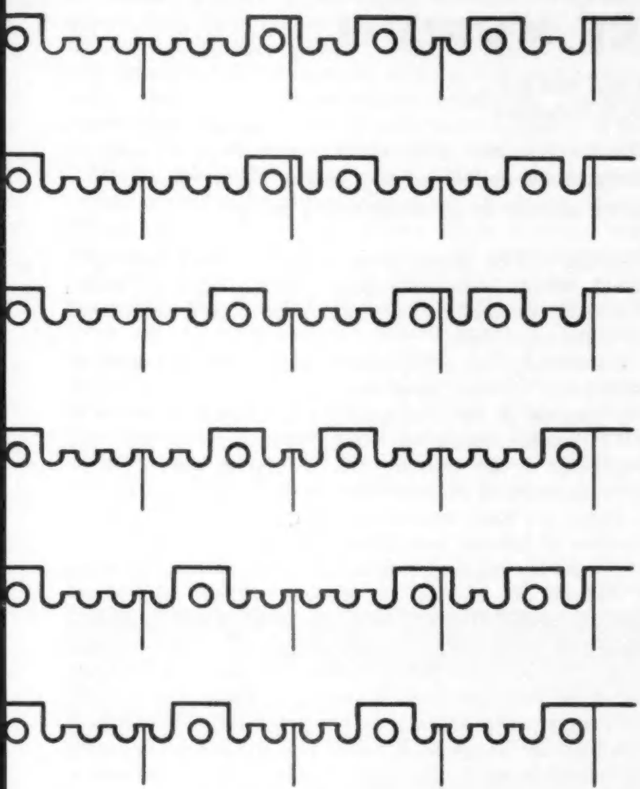
FIRST SYSTEM





To meet A's condition we stab hole A, and of the cards which rise we stab hole D and reject the ones with a slot. Taking the remaining cards we satisfy B's condition by stabbing hole B, lifting, stabbing D and lifting, and rejecting the ones which drop when we stab C. C's proviso is handled as A's was; and E's is dealt with by removing the cards with holes for E and C, and then the cards with holes for E and A. Finally F's views have to be met. Lift out the cards with a hole for F, the ones with a hole at A or B are kept,

SECOND SYSTEM



FIGS. 1 and 2. An "*and*" operation in progress. Six holes are being used. Cards with a hole in position two have been lifted up; the operator is now seeking the ones which also have a hole in position four.

and the rest removed; and then out of this same set of cards (that is, with a hole for *F*) we lift the ones with a hole for *D*, and these are to be rejected unless they also carry a hole for *E*.

This leaves a number of cards from which the ones with just three holes must be selected. There are only two of these, showing that the delegation may be composed of Brown, Ellis, and Finch, or of Brown, Cook, and Finch, and in no other way.

SSHS, SSSH, HSSS, SHSS

Another popular type of puzzle is the "Who's Who" problem, where a number of people do particular things, and they have to be identified from the clues provided. The following example, taken from Hubert Phillips,* is typical.

The Four Smiths. "These four Smiths are very confusing," I said to Mrs Probe, the Professor's wife. "Am I right in thinking that Fred Smith is your grocer, Tom Smith your baker, Joe Smith your milkman, and Harry Smith your butcher?"

"No," said Mrs Probe, "you've got every one of them wrong. And here are some more facts for you. Fred is not the butcher, Joe is not the baker, Fred is not the baker if Joe is the butcher. Joe is not the grocer if Harry is the baker. And if Fred is the baker, Harry is not the milkman. Now can you work out who's who?"

* "Heptameron", Hubert Phillips, Eyre and Spottiswoode, 1945.

For this type of problem a different type of punching is more convenient. We use cards with n^2 holes punched so that all factorial n arrangements of n objects are displayed in code. In this example $n=4$; one card is punched SSHS, SSSH, HSSS, SHSS corresponding to the permutation 3412, and there are 24 cards in all. Incidentally, problems involving five persons on this system require 120 cards, and this is already a trifle unwieldy for a home-made machine. We take the first four holes to indicate Fred's possible trades, the next four for Tom's and so on. It is immediately clear that a number of the clues enable certain holes to be stabbed and the cards removed by a single operation, but the last three statements have to be handled by compound operations on two holes of the types already described.

The main theoretical interest in the particular example given is that it contains redundant information. Two of the clues are superfluous. It is precisely in situations like this that the advantage of card methods shows up. The problem can be attempted using the clues in various orders, and it will sometimes be found that only one card remains (bearing the solution) while some clues still have to be used. These clues are redundant. They may, of course, even be contradictory, in which case ultimately no cards remain and the problem is impossible.

MULTIPLE SOLUTIONS

Cards not only enable redundant clues to be found fairly easily, they also find multiple solutions automatically. The very first problem contained a multiple solution, and so does the next one. It also displays another feature. Cards can just as well handle puzzles in which a certain number of the given statements are known to be false.

My four friends, Mr Flute, Mr Horn, Mr Oboe, and Mr Sackbut form a musical quartet. They play instruments of the same names, but I can never remember which plays which. One day I ask them, and to puzzle me they each give me two pieces of information, one false and one true (but of course I do not know which is which).

Mr Flute says, "I play the horn, and Oboe plays the sackbut."

Mr Oboe says, "Horn plays the flute, and Sackbut plays the instrument bearing my name."

Mr Horn says, "I play the sackbut, and Flute plays the oboe."

Mr Sackbut says, "Oboe plays the flute, and I play the horn."

What can I decide about their respective instruments?

This puzzle can be solved with the same set of 24 cards as before, and statements have to be interpreted according to the pattern, "Either Flute plays the horn and Oboe does not play the sackbut, or Flute does not play the horn and Oboe plays the sackbut." If the clues are worked through in this way, and the cards sorted appropriately, then one ends up with just two cards. These give the solution that Flute, Sackbut, Horn, and Oboe play horn, oboe, sackbut, and flute respectively, and another solution with the names of the men and their instruments interchanged.

A NEW AERONAUTICAL GALLERY AT THE SCIENCE MUSEUM

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For many years the Science Museum's aeronautical collection has been inadequately housed. As part of the general plans for extending the Museum's buildings, a new gallery is being built to house the collection which has already done so much to interest students in aeronautics as a career.

The aeronautical collections at the Science Museum are at last to have a permanent home designed specifically for them. From 1928 to 1950, with a gap of many years for war-time evacuation, they were on the ground floor of the main building in Exhibition Road, where the ceiling height was only 22 ft. and aeroplanes of any size had to be wound round the pillars supporting the ceiling at 25 ft. intervals. In 1950, room had to be made for the Festival of Britain Science display and the collection was moved to a newly redecorated store 300 yards from the main building. In a space only 30 ft. wide by a tenth of a mile long a remarkably fine job was done to provide a display attractive to the public; but nobody would wish to claim much for a building that was supposed to be temporary ninety years before.

This old building is due to be pulled down in 1961 to make way for the extensions of the City and Guilds Engineering College. These are destined to provide post-graduate research workers in aeronautics, and the Science Museum may justly claim that it had been responsible for setting the feet of innumerable young men and women on paths leading to careers of this kind. Apart, therefore, from ordinary considerations of value to the public and to the industry the continued development and exhibition of the aeronautical collections is essential as an important factor in attracting students towards a career in aeronautics. The second phase of a three-phase extension to the main Science Museum buildings recommended by the Bell Committee of 1912 and postponed many times by war and economic crisis, is therefore about to be completed. The basement and ground floor built for the Festival of Britain is to have three more floors added to it, the top one containing a hangar-type gallery. The arches, 30 ft. high, have an unobstructed span of 80 ft. over a length of 225 ft. A senior architect of the Ministry of Works (Welbury Kendall), is collaborating closely with the museum officers concerned in this and other collections involved to produce something in which contemporary improvements in display techniques and educational methods will not be out of place.

A model of the proposed new aeronautical gallery has been built at a scale of ½ in. to a foot after finding that smaller scales did not give a true impression. The suspended aircraft can be viewed not only from ground level but also from a catwalk 8 ft. above, which will be carried by the exhibition cases in which historical relics and small-scale models will be housed. All show cases will be of the shop-window type and will be internally lit. Much more use will be made of background material in arranging the displays, and selected groups of models will be arranged in such a way that they convey information about their place in aeronautical history. Models of fighter aeroplanes, for instance, will be placed along a curve showing increase in speed, while other performance factors will be shown separately for each model. All models in such groups will be to the same scale.

Historically more important objects will be treated in such a way that they stand out from more routine examples. The models of the Montgolfier and Charlier balloons of 1783—which caused so much excitement at the very beginning of aerostation—will be shown against backgrounds based on contemporary prints.

There is a limit, which has already been reached, to the number of full-size aircraft that can be shown. Size alone precludes the acquisition of a D.C.3 or a Viking, let alone a Viscount or a Comet. The decision has been made therefore, to stop at World War II with emphasis on the Battle of Britain. A Spitfire, a Hurricane, and the Gloster/Whittle E.28/39 (forerunner of the Meteor) form the final group, but room has also been found for a Messerschmitt 163 (rocket-propelled fighter), a V.1, a V.2 (on the roof outside) and the Japanese Baka suicide bomber which might be regarded as a man-guided missile. It is, however, possible to accommodate components of later aircraft and such things as wing sections with flap operation, oleo legs, hydraulic controls and ejector seats are already being made, and will be shown as exhibits by various firms.

One of the historic machines of which the Science Museum is particularly proud is the Vickers Vimy in which Alcock and Brown first flew the Atlantic non-stop in 1919. In the new gallery this can once more be shown complete with its wing-tips, and a replica of the cockpit will be made to show the primitive controls and instruments of the time. By contrast the nose portion of the fuselage of the Canberra in which Beamont and his crew first crossed the Atlantic non-stop twice in one day in 1952 has just been presented by the English Electric Co.

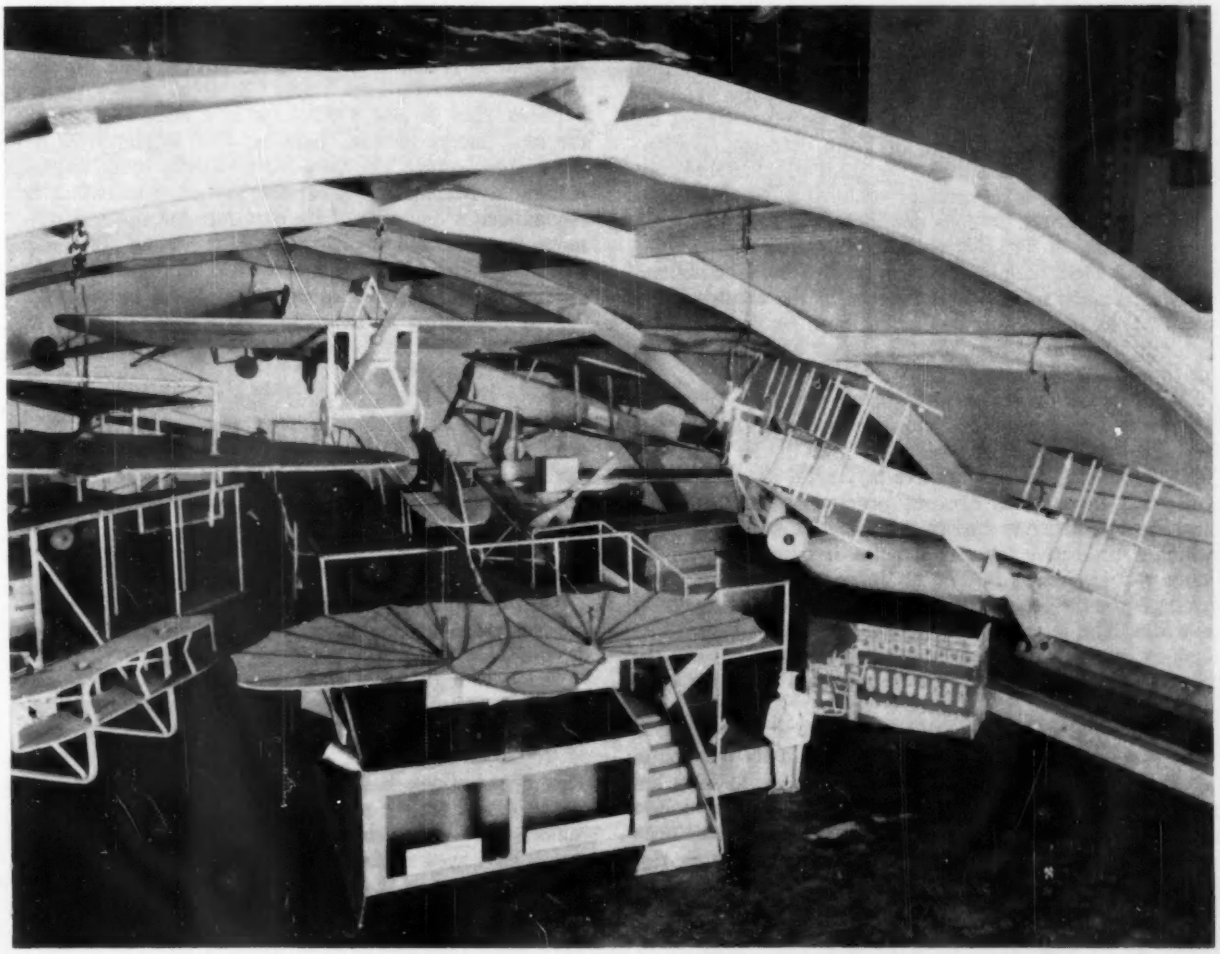
Provision is being made in the new gallery for the accomodation of wind tunnel and smoke chamber exhibits. The latter is in an advanced experimental stage, but the former, of which an excellent design exists, depends upon the availability of funds. A section on aerodynamics would appear to be indispensable if the right type of student is to be steered into the profession for which the College extensions are being built. It is by no means easy to show aerodynamics as a museum subject but the planning so far, in every aspect other than finance, has not been at all discouraging. Buildings, cases, furnishings and so on will account in all for perhaps a million pounds of public money over the next few years and it is to be hoped that industry, which has contributed large sums for the development of a number of the other museum collections over the past years, will again be ready to help. In the case

of aeronautics, the industry is facing difficulties and there are competing claims for a National Aeronautical Museum project, but with an annual attendance of over 1,250,000 the Science Museum provides what is undoubtedly the very cheapest form of incentive to those who may be hesitating over a career in science or technology. The steel industry has just spent £60,000 on one new gallery in the museum.

On the historical side, the museum has some interesting aerodynamical material including relics of Cayley, Stringfellow, Horatio Phillips, and others. There is also a very good historical series of engines, from the steam engines of Stringfellow (1848) and Maxim (1894) to a replica, using an original aluminium crankcase, of the Wright engine of 1903, and a whole series of pioneer types such as the Anzani, Gnôme Rotary, Antoinette, and Green. The original Whittle W.1 jet engine of 1941 precedes a whole series culminating, at present, in a Bristol Proteus. Negotions have just been concluded and funds from museum resources have been made available for the reassembly of an original Rolls-Royce vertical uplift thrust measuring device, more commonly recognisable as The Flying Bedstead of 1954, out of two examples in the possession of the Ministry of Supply. The Museum is fortunate in having the active support of this Ministry in building up its collections. Rocket motors are represented, but work has yet to begin on a rocketry section for which space has been allocated.

With the staff and facilities available it will be a long job to bring the new gallery up to the final standard aimed at, but with the enthusiastic co-operation of some firms in the industry substantial progress is being made. When the new gallery opens in 1962 after a period of total closure which will be limited, if possible, to not more than six months, there will be plenty to see, and plenty still to do. The Science Museum was 100 years old last year. We have been taught always to plan for the next 100 years, and if our decisions are as wise as some of those that have been taken in the past, we and our successors should be well satisfied. The span of human life is such that we can never know, but at least our very large number of visitors encourages us to hope that we are going the right way.

FIG. 1. A model of the entrance to the planned new gallery showing historic aircraft and access to catwalk.



MODERN DEVELOPMENTS IN INFRA-RED RECORDING

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During the war infra-red image converters were used by the armed forces for "seeing in the dark". These and other techniques for making infra-red images visible have advanced rapidly and are bringing greater flexibility to photography, cinematography, and television.

Since Sir William Herschel[1] first demonstrated the presence of radiation beyond the visible red, the main properties of infra-red radiation have come to be recognised as: different absorption and reflection by pigments, when compared with the effect of visible light; greater penetration of cellular tissues and of haze; inability to stimulate the retina, both human and animal. Applications range from the recording of long-wave emission in temperature mapping and in spectroscopy to the use of shorter wave radiation in aerial photography, and in forensic, medical, and biological investigations.

DIRECT RECORDING

The use of infra-red-sensitive photographic emulsions is perhaps the best known method of infra-red recording. One or two emulsions have been commercially available since the nineteen-twenties. However, the post-war era has brought a profusion of materials from different manufacturers, and the tabular survey (Fig. 3.) is an attempt to compare the emulsions at present obtainable from different parts of the world. It does not include special plates for block-making or for spectroscopy, but shows twenty emulsions from eight manufacturers in seven different countries. It is interesting to note that thirteen of the emulsions are available as plates, only one as cut film, six as 35-mm. or roll film, three as 35-mm. motion picture film, and only one as 16-mm. cine film.

The Russian 35-mm. motion picture film Type 2[2] is used for the Traveling-Matte technique in entertainment cinematography. Its maximum sensitivity lies in the region of 8050–8100 Å. It consists of three layers, the lowest contains colloidal silver which absorbs penetrating infra-red rays and the middle layer carries the sensitive emulsion on to which a protective layer of gelatine has been coated. An actor is filmed in front of an infra-red reflecting background, and the colour film is exposed in front of the infra-red film. The latter is then reversal processed to form an opaque mask with clear surround through which the required background can now be recorded on to the same colour film.

The spectral sensitivity extends to 9000 Å and beyond in only two examples, and the average sensitivity terminates at about 8700 Å. The maximum sensitivity to infra-red radiation appears to vary from a low 7200 Å to a modest 8600 Å, although a sensitivity up to 13,000 Å has been achieved for special purposes. Further advances in this direction are difficult to imagine, as radiation from the packing material, camera, and processing solution would be likely to have an adverse effect on the film.

Resolving power is so dependent in the test object employed that it is not possible to quote reliable figures. Some claims have varied from a conservative 20 lines per millimetre to an optimistic 100 lines per millimetre. However, it is quite fair to compare most of these materials with fast panchromatic emulsions.

Definition is limited by the rather large grain size associated with most infra-red negatives, but a ×4 magnification can usually be obtained without undue loss of definition.

Film speed is difficult to assess, particularly in daylight where the amount of infra-red radiation available must depend on the effective contribution of direct sunlight. For artificial lighting a few tests with photoflood or flash bulbs will lead to predictable results. Electronic flash discharge tubes can also be used. Here the total energy emitted, between 7200 Å and 8700 Å, is in a ratio of 1 : 3 with the total energy radiated between 4000 Å and 7000 Å in the visible region.[3] The infra-red sensitivity of an emulsion is liable to decrease fairly rapidly, and some manufacturers recommend a doubling of the exposure for material stored more than six months. Storage in a normal refrigerator will retard this deterioration, whilst deep freeze can be relied upon to preserve an emulsion almost indefinitely.

It is interesting to note that one Eastman Kodak and the Gevaert film claim relatively high speed ratings, 80 and 100 ASA respectively.

Image contrast can be quite high, up to $\gamma 1{\cdot}8$, with suitable processing. Except where phenomena are to be recorded in total darkness, continuous tone reproduction can be neglected in favour of clear differentiation between the characteristic absorption and reflection of infra-red radiation by the object under examination.

INDIRECT RECORDING

The following brief survey of the various methods of indirect infra-red recording includes a number of recent developments.

The Latent Herschel effect is mentioned only for completeness. The latent photographic image, created in a normal emulsion by exposure to short wavelengths, can be destroyed by subsequent irradiation with infra-red waves. This phenomenon has been used in spectroscopy up to 10,140 Å and for the preparation of direct positives in the camera. The procedure is very critical indeed, and full details have been published by Walter Clark.[4]

Volatilisation or Evaporography was first used by Sir John F. W. Herschel in 1840. Very thin paper was made heat-absorbing by coating with lampblack. Alcohol was

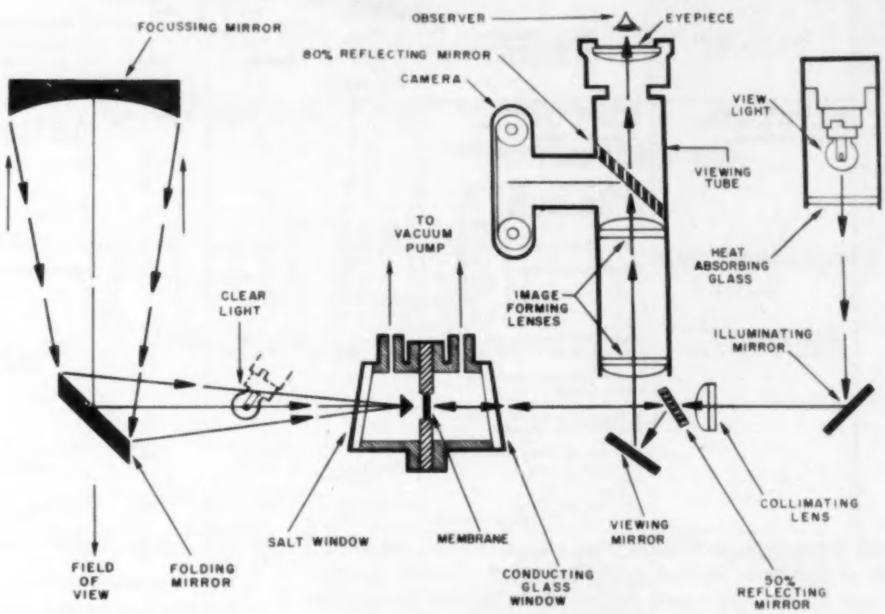


FIG. 1. Diagrammatic representation of the Baird Atomic Evaporograph.

applied to the back of the paper, which was then exposed to radiation. Heat from infra-red lines caused the alcohol to evaporate more quickly. It was found that dyes incorporated in the alcohol were deposited more readily in areas of rapid evaporation. Czerny[5] in 1929 evaporated camphor and naphthalene on to a thin membrane enclosed under low pressure. Where infra-red was absorbed, sublimation caused a change in thickness and thus a change in interference coloration. Lines up to 60,000 Å and eventually up to 90,000 Å could be recorded by this method.

A recent development was briefly mentioned in DISCOVERY, 1956, vol. 17, p. 186. The Evaporagraph[6] manufactured by Baird Atomic Inc., of Cambridge, Mass., U.S.A., relies entirely on radiation emitted by the object to be recorded, As the diagram in Fig. 1 shows, the apparatus contains an evacuated cell between two mirrors which reflect the image into the cell, an optical viewing system, and a camera. The cell is divided by a nitrocellulose membrane, 4 micro-inches in thickness, and coated with evaporated gold on one side to absorb radiation. One half of the cell carries a small quantity of oil which is at a slightly higher temperature than the cell membrane, so that the oil will condense on to it. Wherever heat radiation is focused on to it the membrane will register an increase in temperature. This will affect the interference colour which can be recorded by the camera, thus yielding an image of the object. Temperature differences can be measured by the observed rate of evaporation at temperatures above 80°C and by the rate of condensation at 80°C or below. The rate of evaporation, observed as a change from purple to red, orange, yellow, light blue, and light green, will depend on the temperature difference between the subject and the membrane. A difference of 30°C will form an image in 15 sec., but a difference of 600°C is established in a mere fraction of a second. Direct visual examination may be preferable to evaluation from the photographic records which suffer from poor definition.

The same defect appears to be connected with the system

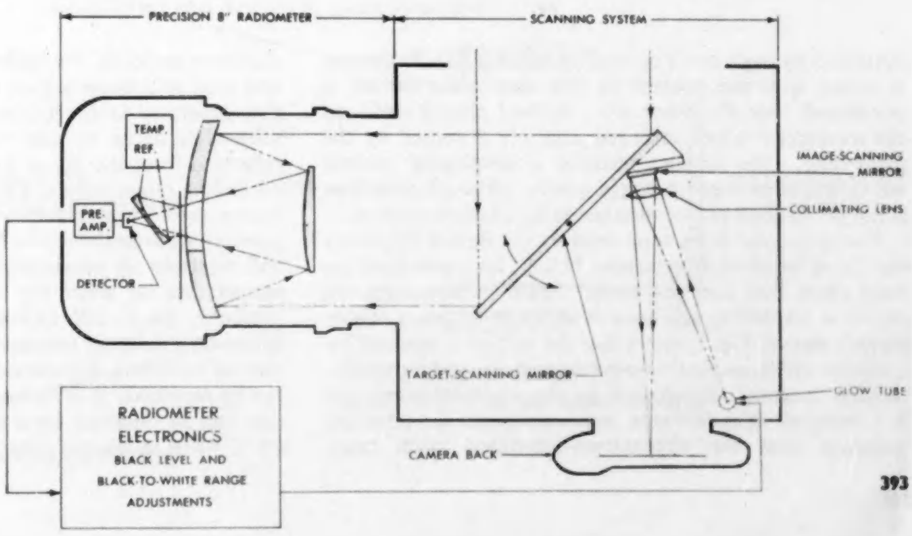


FIG. 2. Working diagram of the Barnes Engineering Thermograph.

Name and Address of Manufacturer	Name of Emulsion and Sizes Available	Extent of Spectral Sensitivity and Maximum Sensitivity (Å)		Approximate Emulsion Speed: ASA with filter specified				Recommended Filters and Beginning of Transmission	Recommended Safe Light for Brief Inspection Only	Recommended Development to γ 1.8 (with continuous agitation)
		Up to	Max.	Daylight		Tungsten				
VEB Filmfabrik Agfa, Wolfen, Kreiss Bitterfeld, Eastern Germany.	Infra-rapid Film 750 35-mm. film in 36 exposure cassettes, 5 metre rolls; 120 metre or 300 metre rolls for kinematography.	8,500	7,600	*Agfa* 82 12	*Agfa* 83 6	*Agfa* 82 25	*Agfa* 83 10	Agfa 82 at 6,300Å Agfa 83 at 7,100Å	Agfa 108	Agfa 1. 5 min., 65°F.
	Plates in sizes: 6.5 × 9 cm., 9 × 12 cm., 13 × 18 cm., 18 × 24 cm.									
	Agfa-infrarot Platte 700 Rapid	7,500	7,200	5	—	10	—	Both filters apply	Agfa 108	Agfa 1. 5 min., 65°F.
	Agfa-infrarot Platte 700 Hart	7,500	7,200	3.2	—	10	—			Agfa 15. 10 min., 65°F.
	Agfa-infrarot Platte 750 Rapid	8,300	7,700	5	2.6	5	3.2			Agfa 1. 5 min., 65°F.
	Agfa-infrarot Platte 750 Hart	7,900	7,550	3.2	2	5	5			Agfa 15. 10 min., 65°F.
	Agfa-infrarot Platte 800 Rapid	8,550	8,200	2.6	2.6	5	3.2			Agfa 1. 5 min., 65°F.
	Agfa-infrarot Platte 800 Hart	8,600	8,300	2	1	5	5			Agfa 15. 10 min., 65°F.
	Agfa-infrarot Platte 850 Rapid	8,900	8,500	1	2	2	2			Agfa 1. 5 min., 65°F.
	Agfa-infrarot Platte 850 Hart	9,000	8,600	1	1	2	2.6			Agfa 15. 10 min., 65°F.
Eastman Kodak Co., Rochester 4, N.Y., U.S.A.	High-speed infra-red film No. 546:16 mm., 100 ft. spool. HIR.402:35 mm., 100ft. roll, wooden core. HIR.408:35 mm., 100 ft. roll, modified; No. 10 spool.	9,700	8,000	*Wratten* 87 25		*Wratten* 87 80		Wratten 87 at 7,400Å	None	D.19 7 min., 68°F.
	Infra-red sheet film. All regularly listed sheet film sizes.	8,700	8,000-8,400	6		10		Wratten 87 at 7,400Å	Wratten Series 7	D.19 7 min., 68°F.
	Infra-red Film IR.135 35 mm. film 20 exposure cassettes.	8,700	8,000-8,400	6		10		Wratten 87 at 7,400Å	Wratten Series 7	D.76 15 min., 68°F. (γ 1.4 only)
Ferrania, Corso Matteotti 12, Milan, Italy.	I. 7200 7,200 infra-red film: 35-mm. film 36 exposure cassettes, 36 exposure refills, 5 metres; 35-mm. kine film in packs suitable for Eyemo, Arriflex, Debrie-Mitchell cameras.	7,700	7,200	*R*.102 2.5		*R*.102 10		R.102 at 5,900Å	Ferrania 20	R.6 10 min., 64°F.
	I.7200 7,200 infra-red plates all standard sizes.	7,700	7,200	*R*.102 2.5		*R*.102 10		R.102 at 5,900Å	Ferrania 20	R.10 16 min., 64°F.
	I.8300 8,300 infra-red plates all standard sizes.	8,500	8,300	*R*.103 1.6		*R*.103 10		R.103 at 6,100Å	Ferrania 20	R.10 15 min., 64°F.
Gevaert Photo-Producten N.V., Mortsel, Antwerp, Belgium.	Scientia 52 A 86 Film: 35-mm. film 36 exposure cassettes, and 120 roll film. Plates: all standard sizes.	8,980	7,800-8,000	*R*.719 80		*R*.719 100		R.719 at 7,190Å	Gevinal × 535	G.201 3 min., 68°F. (maximum γ 2.7 is reached in 10 min.)
R. Guilleminot, Bœspflug & Cie., 22, Rue de Chateaudin, Paris 9e, France.	Infra Guil Plates: 6.5 × 9 cm., 9 × 12 cm., 13 × 18 cm., 18 × 24 cm.	8,650	8,000	*Wood* 88 8		*Wood* 88 16		Wood 88 at 7,400Å	None	GB.24 4 min., 65°F.
Kodak Ltd., Wealdstone, Harrow, Middlesex, Great Britain.	IRER (Kodak Infra-Red Extra-Rapid) Plates: 2½ × 3½ in., 3¼ × 4¼ in., 4 × 5 in., 4 × 10 in., 4¾ × 6½ in., 6.5 × 9 cm., 9 × 12 cm. Other sizes up to and including 10 × 12 in. to be ordered under Kodak Scientific Plate II—N.	8,800	8,000	*Wratten* 87 6		*Wratten* 87 10		Wratten 87 at 7,400Å	Wratten Series 9	D.19b diluted 1 + 2 5½ min., 68°F.
Kodak-Pathé, 37-39 Avenue Montaigne, Paris 8e, France.	Infra Rouge 5512 35-mm. film 20 exposure cassettes.	8,800	8,200	*Wratten* 87 6		*Wratten* 87 10		Wratten 87 at 7,400Å	Wratten Series 7	D.19b diluted 1 + 1 6 min., 68°F. (γ 0.9 only)
Konishiroku Photo Industry Co., No. 1, 3-Chome, Muromachi, Nihonbashi, Chuo-Ku, Tokyo, Japan.	Sakura Infra-red Film 750 35-mm. film 20 exposure dark room loading. 120 roll film, 8 exposures.	8,200	7,500	Any filter cutting up to 5,600Å 6		Any filter cutting up to 5,600Å 10		Any filter cutting up to 5,600Å	None	D.76 9 min., 68°F.

FIG. 3. Comparative survey of available infra-red emulsions.

described by Suga and Yosihara[7] in which a thin membrane is coated with metal black on one side, while aerosol is positioned near the other side. Aerosol cannot settle on the membrane where infra-red rays are absorbed by the membrane. The authors mention a developing process which is said to improve image quality, although definition is not yet as good as that obtainable by Czerny's method.

Thermography is the term used by the Barnes Engineering Co. of Stanford, Connecticut, U.S.A., for a new development which they have pioneered.[8] Again invisible infra-red radiation emitted by an object is transformed into a photographic record. Fig. 2 shows that the subject is scanned by a mirror which oscillates both horizontally and vertically. Incident radiation is reflected by the scanning mirror on to a detector, or radiometer, which compares the infra-red radiation with the temperature-controlled black body radiation standard. The difference in potential is amplified and used to activate a glow modulator tube. Visible light, thus generated in direct relation to the heat emitted by the subject, is made to scan the photographic emulsion by reflection from the image mirror which is attached to the oscillating target mirror. The last few sweeps of the image mirror record a grey step-wedge which indicates the temperature scale on the record for quantitative analysis. White will represent all temperatures at and above the maximum temperature for which the instrument has been adjusted; similarly, black will represent all temperatures at and below the minimum temperature of the range in use at the time of recording. Temperatures from −170°C to +300°C can be recorded. It is claimed that a distinct photographic tone can be obtained for a temperature difference of only 0·5°C when an overall range of 4°C is used. Definition is

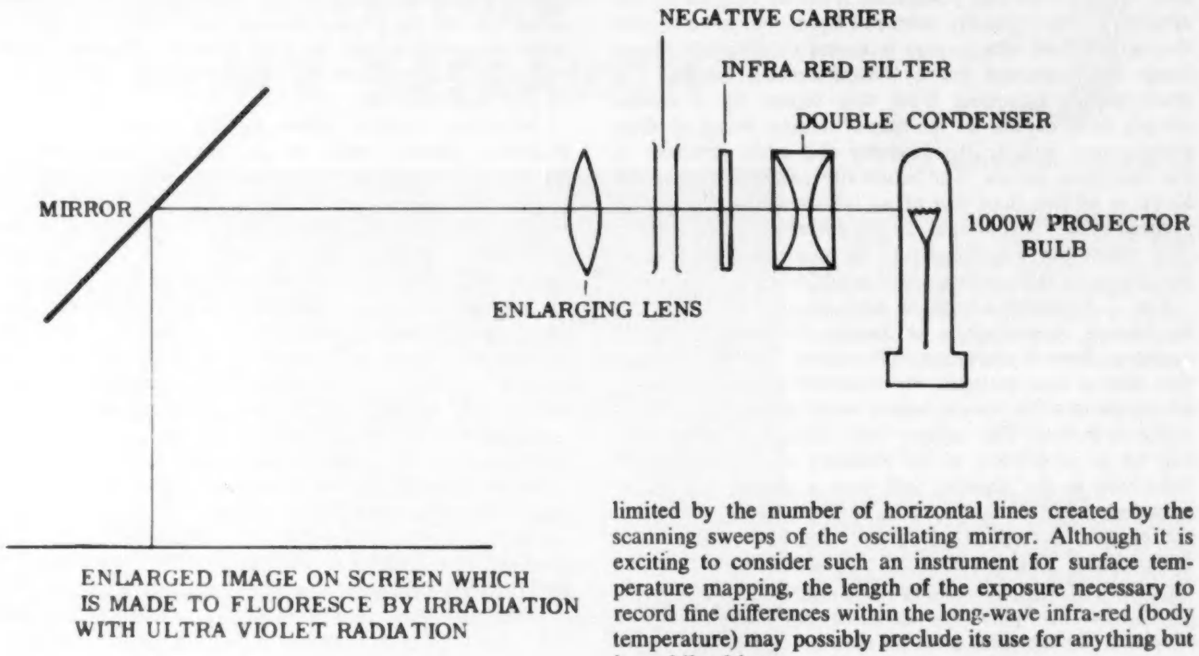


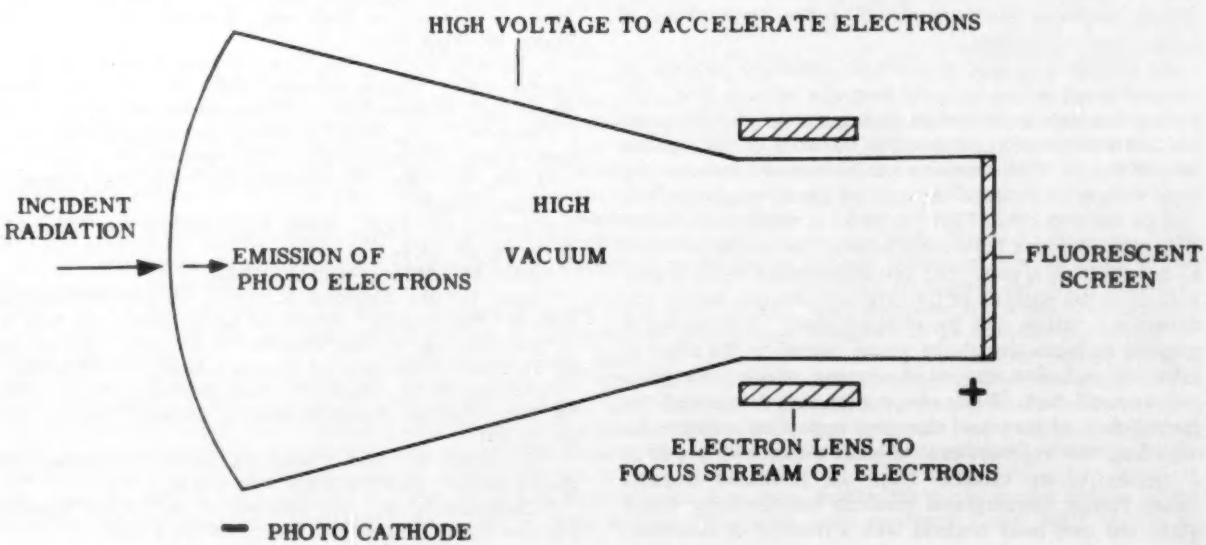
FIG. 4. A diagrammatic representation of the Vertoskope.

limited by the number of horizontal lines created by the scanning sweeps of the oscillating mirror. Although it is exciting to consider such an instrument for surface temperature mapping, the length of the exposure necessary to record fine differences within the long-wave infra-red (body temperature) may possibly preclude its use for anything but immobile objects.

Harding *et al.*[9] have described a thermal image converter which is based on the dependence upon the temperature of the absorption threshold in a semiconductor. Where an object can be trans-illuminated by monochromatic light of a wavelength near the threshold, any variations in temperature will appear as differences in intensity of the transmitted light.

Phosphorography was first used seriously by Becquerel[10] in 1842 for spectroscopy. The gradual decay of phosphorescence, after the source of excitation has been extinguished, can be greatly accelerated by irradiation with infra-red. Becquerel was able to see infra-red lines up to 13,000 Å. This limit has since been advanced to 20,000 Å. Apart

FIG. 5. Principle of the Image Converter Tube.



from spectroscopy, the phenomenon can be used for photography. A high-intensity infra-red beam will have to pass through the lens of a camera to create a sufficiently strong image by extinction on a phosphorescent screen. The photographic recording from this screen by a second camera must depend on the rate of natural decay of phosphorescence, and on the intensity and grain structure of the luminous screen. The sensitivity of such a screen is likely to be less than that of an infra-red-sensitive photographic plate. This system should therefore be considered only when the wavelengths to be used are too long to register on an infra-red-sensitive emulsion.

Fig. 4 illustrates a modern application, the Vertoskope by Meteor Apparatebau of Siegen, Germany. Infra-red radiation from a projection bulb passes through the negative, and a lens projects the infra-red image via a 45° mirror on to a fluorescent screen which is excited by ultraviolet radiation. The image, thus created by extinction, will be in proportion to the densities of the negative. A light area in the negative will pass a greater amount of infra-red, when compared with higher negative densities, and cause a correspondingly greater degree of extinction of fluorescence. This reversal of tone-values results in the formation of a positive image. The apparatus has already found a serious application in the sorting of large numbers of aerial photographs prior to detailed study for intelligence purposes, without the necessity for positive photographic prints. Negatives on sheet or roll film up to 3¼ in. in width can be accommodated in the negative carrier which permits rotation through 180°. Linear magnification of the image is ×2½. A similar, though less streamlined, device has been in use for a number of years in the research laboratories of the former British Thomson-Houston Company. A recent patent describes the use of this principle for automatic shading or "dodging" during photographic contact printing.

The image converter is indeed a development of the electronic age. Since Zworykin and Morton[11] described the principles and possible applications, infra-red image converters were used extensively by both sides during the last war for detection and aiming in the dark. Since the war greater emphasis has been placed on the development of X-ray image intensifiers.

As indicated in Fig. 5, infra-red radiation projects an image through a lens on to the face of a cathode tube. The surface has been sensitised in such a manner that electrons are liberated in proportion to the intensity of the incident infra-red rays. The electrons are accelerated *in vacuo* by high voltage and passed through an electromagnetic field, and an electron optical lens, to strike a small metal target. This is backed by a fluorescent screen. The energy liberated by the electrons is converted into fluorescence, again in proportion to the intensity of the original infra-red image. The fluorescent screen can be photographed. This makes it possible to focus sharply by visual means on the effect of infra-red radiation or on phenomena which take place only in total dark. When observation has determined the desired field of view and the most opportune moment for recording, the exposure can be made either with a still or a motion-picture camera. Until an increased demand makes further development research commercially worth while, the user must contend with a number of disadvantages. The graininess of the fluorescent screen limits definition. At the present time it is still difficult to prevent metal evaporation into the high vacuum. This affects the sensitivity and working life of the tube, and the defect is largely unpredictable.

Television camera tubes exhibit a broad spectral response. Recent work in the research laboratory of Electric and Musical Industries Ltd, Great Britain, has led to the development of a vidicon tube with an effective response to 10,000 Å and beyond.

The infra-red image is projected on to a target layer of photo-conductive, specially sensitised material. The degree of conductivity is a function of the incident radiation intensity. The layer is charged by an electron beam, and some of this charge will leak away between scans wherever radiation falls on to the layer. The scanning beam will restore such losses, and the pulses produced in the process constitute the picture signal. This is transformed into an electron beam of related intensity at the receiving end, where it will cause fluorescence in proportion to the amount of radiation received from the subject.

The EMI tube compares more than favourably with standard infra-red sensitive photographic emulsions. A good picture quality with a good signal-to-noise ratio can be obtained with a 1-in. lens at $f/4$, using a Wratten 87 filter and a 500-watt photoflood lamp on either side of the subject and at a distance of 3 ft. Depth of field is good compared with an 8-in. lens at $f/8$ which would be required with half-plate Kodak IRER plates. Resolution is, of course, severely restricted by the television receiver system.

As the tube will fit into standard industrial-type television cameras, it will be obvious that its reliability and general flexibility makes it a more practical proposition than the present-day image converters described above. The use of this equipment should commend itself to all those who wish to observe before they record, particularly phenomena which require total darkness.

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GEOPHYSICS AND SPACE RESEARCH

By ANGELA CROOME

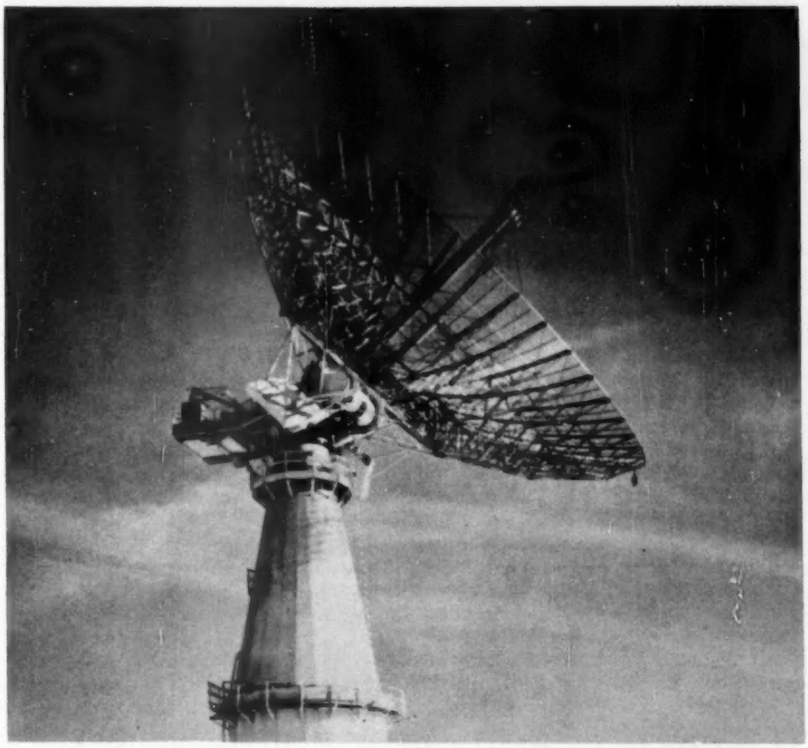


FIG. 1. The Millstone Hill 84-ft. radar, which is operated by the MIT Lincoln Laboratory under contract to the United States Air Force, will attempt to scan the surface of Venus at the close approach of the planet during September. This was the instrument that succeeded in getting a radar echo off the same planet for the first time in February 1958. Venus's surface is completely unknown as the planet is permanently surrounded by cloud. Jodrell Bank has a similar programme for September's close approach.

Britain in Space

The agreement made between the British space team, led by Prof. Massey, F.R.S., and the American civilian space agency (which was negotiated in June) is sensible but modest. The arrangements were announced in Parliament by Lord Hailsham, Lord President of the Council, on the day before the recess (July 29). They provided for the firing of three or four American satellite-launching *Scout* rockets in the period 1961 to 1963–4 using American facilities but carrying British experiments.

We need expect no dazzling discoveries from the programme. We need not even rely on priority within the Commonwealth in having a payload in orbit. This is in essence an apprentice scheme for the real thing. As such it has everything to recommend it. It is cheap, convenient, and starts at once. "It will enable us to get our feet wet at very little cost to ourselves," as Sir Edward Bullard, F.R.S., chairman of the Government steering committee on space research, has put it. The cost amounts up to £200,000 a year for the next four years. Compare this total with the estimated £2½ million cost of each *Vanguard* fired, and the Treasury's keen accounting can be appreciated.

It would be as well for us to realise that in relation to this technique of obtaining information from space by placing a vehicle there we are still beginners. American scientists have been able to draw on ten years' experience with sounding rockets. The Russians on at least that. In contrast, the full scientific programme with *Skylark* is little more than a year old. Now the *Scout* scheme will enable our scientists to accumulate experience in readiness for the appearance of *Blue Streak* as a satellite-launcher when the projected design study to be prepared by Ministry of Supply scientists is complete. It cannot be expected that anyone here will be content to use "borrowed space" indefinitely. Meantime, the present formula for making a smooth transition, and the Americans' generosity in the matter, is most welcome.

The Sun's Helium Atmosphere

Following the success of the U.S. Naval Research Laboratory's attempt in March to photograph the Sun's hydrogen atmosphere in ultra-violet light from a rocket (see DISCOVERY, July, No. 7, vol. 20, p. 282), the same group, under the leadership of Dr Herbert Friedman, now plans to photograph the Sun's helium atmosphere at even shorter wavelength. This component of the solar "weather" lies yet farther out from the Sun's visible disc —where the outer layer of the chromosphere melts into the inner layer of the corona. Reading up through the different layers of the Sun's atmosphere (as far as this is possible from the photographs at various wavelengths now available), the picture is of increasing gas turbulence and rising temperature.

The Naval Research Laboratory's March photograph of Lyman-alpha hydrogen (the highest level of the solar atmosphere so far photographed across the whole face) showed a strikingly stormy Sun. If this pattern persists there will be bright emission from ionised helium at a wavelength of 304 Å. Helium does not ionise till a temperature of between 20,000° and 30,000°K is reached whereas a temperature of 6000° to 10,000°K is sufficient to ionise hydrogen.

There is an immediate practical interest in this work. Emission from the Sun's ionised helium is thought to be almost entirely responsible for the F region of the ionosphere. If the details of this relationship can be established it should be possible to plot the solar weather and give predictions of what terrestrial responses—such as optimum transmission frequencies for short-wave radio—may be expected.

The experiment itself is extremely difficult to perform. It took four years to develop the spectrographic camera for the solar hydrogen rocket flight in March,

and, although the all-important photographs were recovered intact, the camera was smashed. The commonly used mirror surfaces are very poor ultra-violet reflectors, so that special coating techniques have to be developed for photographing the Sun in helium ultra-violet light.

Mirrors have to be used in the camera for this work because Lyman-alpha radiation is strongly absorbed by all materials and this would be true of photographic lenses also. Nor are the mirrors ordinary mirrors; they are diffraction gratings ruled to 15,000 lines to the inch. The rulings cause the intense visible light from the Sun accompanying the ultra-violet to be thrown out of the camera and leaving only the monochromatic Lyman-alpha radiation to form the solar image.

Nor can ordinary film be used for such ultra-violet experiments. This is because the gelatine in the emulsion absorbs the radiation under observation before it can reach and expose the silver-halide grains. An extremely fragile film containing no gelatine is used for the work. Once made, the surface can be damaged or removed if touched in any way.

Atmosphere Mapped by Fall-out Studies

The addition of a radioactive tracer, Tungsten-185 (half-life 74 days), to the American *Hardtack* bomb test series from the Marshall Islands (11° N) between May and July last year has confirmed the general picture that has been gaining ground lately of how fall-out actually falls out. The tracer experiment has gone a long way towards settling this controversial issue; similarly that of how the atmosphere mixes, the model of the atmosphere being that put forward ten years ago by the Oxford workers, Dobson and Brewer.

A ground-level monitoring programme on a north–south line through the American continent has shown that although the material was injected into the equatorial atmosphere it is distributed as long-range fall-out principally in the middle region of the northern hemisphere, somewhere in the same region of the southern hemisphere and practically not at all in the tropics. The ratio is 50 : 15 : 2 respectively.

This fall-out pattern substantiates that derived by a variety of other programmes both in the United States and elsewhere employing other techniques. The significance of the Tungsten experiment is that this isotope is not a fission product and was not present in the atmosphere before May 1958. The debris from the American equatorial tests to which it was added can therefore be readily distinguished from that produced by previous tests (whether American, Russian, or British) and from the Russian polar tests that followed *Hardtack* last autumn.

The temperate zones of the northern hemisphere is receiving two and a half times as much of the long-range fall-out as all the rest of the world put together. What is the reason for this preferential treatment? The model of atmospheric mixing that best fits these surprising facts is of a slowly rising column of tropospheric air entering the equatorial region of the stratosphere, spreading poleward, and sinking back into the troposphere mainly in late winter or spring (see diagram). Fission debris flung up into the stratosphere by the larger tests are caught up in this motion, and by tracking these the motions of the atmosphere itself can be mapped. Debris is in suspension until it returns to the troposphere and will not settle out much from there unless washed down by rain. From this it follows the polar regions would receive more fall-out were it not that there is comparatively less rainfall equivalent in those parts than in middle latitudes. Seventy-five per cent of all long-life fall-out has proved to come from the stratosphere and is involved in this banding process.

The details of the mixing of the planet's atmosphere are still confused and will occupy meteorologists and geophysicists for many years, but the general picture now appears beyond dispute. An account of the Tungsten experiment and its interpretation was first presented by Dr Lester Machta of the U.S. Weather Bureau, who was responsible for this work, at hearings before the United States Congressional Committee on Atomic Energy in May.

Large Orbiting Telescope

The new American optical observatory in Arizona, Kitt Peak National Observatory, has just received a $160,000 grant to carry out a "feasibility study" for a 50-in. aperture telescope to be placed in an earth-satellite orbiting several thousand miles up. The functioning lifetime of the orbiting equipment is envisaged as between five and ten years. The sponsors are the National Science Foundation and the observatory group led by Dr Aden B. Meinel, Kitt Peak director, is to work in closely with NASA. The present study is intended to lead to an actual design study for such an instrument. The possibilities of astronomy from space is understood to have transferred Dr Meinel's interest from the design of a 300-ft. telescope in the United States.

A large telescope in orbit well above the Earth's atmosphere is "expected to lead to astronomical discoveries of the greatest importance". The entire ultra-violet, x- and gamma-ray spectrum will be observable (wavelengths shorter than 2700 Å cannot penetrate the atmosphere); the radio spectrum above 20 metres will also be available. Two other

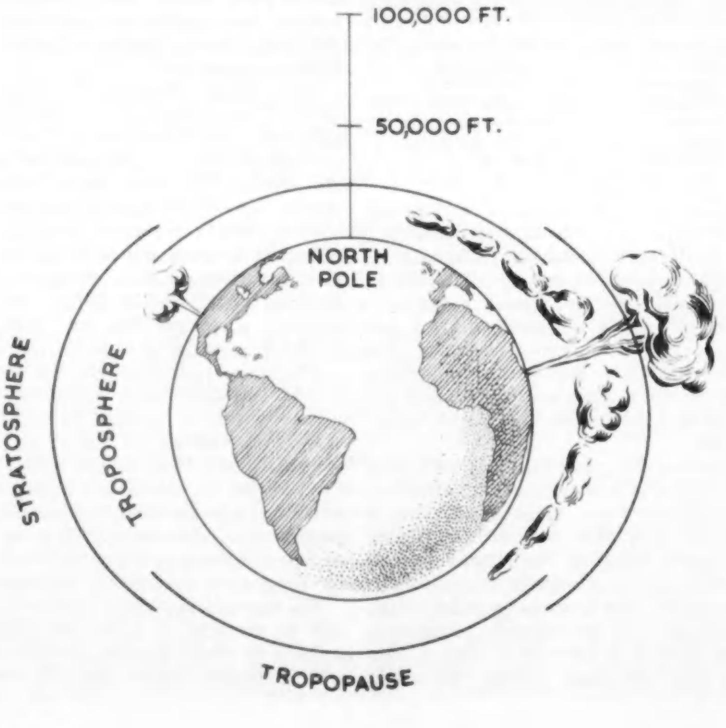
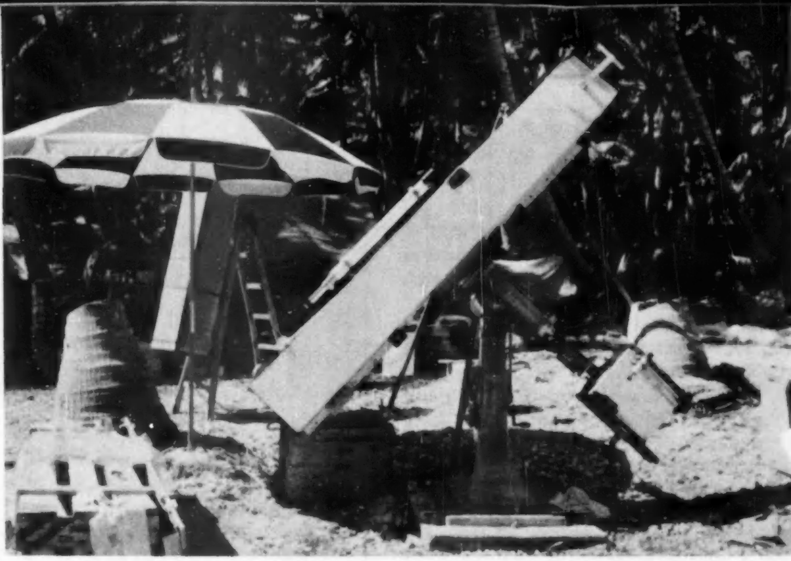


FIG. 2 (*left*). The Earth's Atmosphere. Diagram of atmospheric mixing as inferred from tracing Tungsten-185 artificially introduced into the American *Hardtack* bomb test series in 1958. (*By courtesy United States Weather Bureau*)

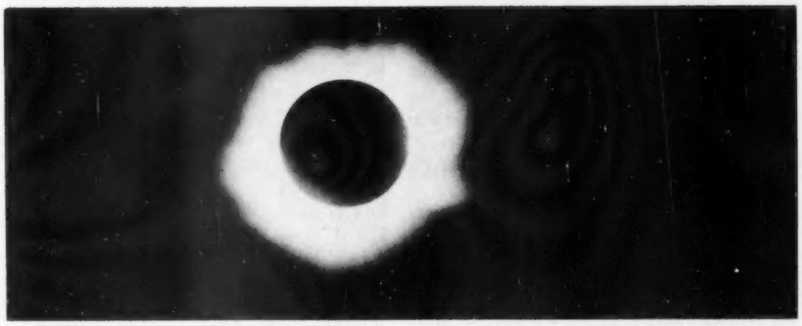


JAPANESE ECLIPSE EXPEDITION

FIGS. 3, 4, and 5. Last October's Japanese Eclipse Expedition to the uninhabited Suwarrow Islands in the South Pacific was lucky over the weather. The heavy stormclouds opened at the last moment before totality and a number of successful observations were possible.

FIG. 3 (*above*) shows a corner of the camp with the two polarisation cameras used by Mr Yamashita and Mr Shimuzu of Tokyo Observatory in coronal measurements on an equatorial mounting.

FIG. 4 (*below*) Photograph of the eclipse showing the white light corona. *(Photograph by Mr Oiwaki of the Hydrographic Bureau)*



Dr Suemoto and Mr Hiei of Tokyo Observatory were interested in the chromosphere and took flash spectra with a dispersion of 2 Å/mm. in the ultra-violet and red regions. The spectrograph was slitless, but as the sunbeam entered the grating obliquely, the whole chromosphere's thickness was jammed into a narrow strip. Both the intensity and the line widths can be measured on the spectrogram (see FIG. 5 *below*).
(Photographs by courtesy Japanese Eclipse Expedition)

groups in the United States are known to have been working on designs for small optical telescopes to be carried in satellites. Prof. Fred Whipple of Harvard has produced plans for a 12-in. equipment and the Air Force Cambridge Research Center is interested in a design of different principle but of about the same size.

Perhaps it is worth noting that the projected 50-in. telescope in space is larger than any telescope at present in operation on the ground in Britain.

Into Space and Back

The first object to be recovered from a space trip in a satellite is likely to be—paradoxically enough—an all-British item. It will be a stack of Ilford photographic emulsions marked by the radioactive particles that swarm round the Earth beyond the atmosphere. The atmosphere prevents them from reaching the surface in their original form.

Such emulsion packets—like a big bunch of letters and about the same size—are being flown regularly in the American *Discoverer* series of satellites. Twelve *Discoverers* are planned for firing at roughly monthly intervals. So far five have been launched of which two failed to orbit. Radio contact was lost with the first, in the other two the instrument package with the emulsions probably did return to Earth but not under the controlled conditions intended, so have not been found.

These satellites have a rather brief lifetime as they are put into rather low orbits, just over a hundred miles high—the sort of orbit that the first man into space will travel in. They are fired almost due south so as to pass over the Poles. Some of them are to carry small animals as well as emulsions. No. 3 had some black mice aboard.

But the most particular feature of the *Discoverers* is that one day one of the payloads will be brought back intact to the laboratory for study.

It is for this reason that emulsions can be used. The information they yield can only be released under the microscope. It cannot be even roughly digested inside the satellite or radioed back—as hits registered by a Geiger counter can. But, embedded in the emulsion is a much more detailed picture of what actually hits it than the Geiger counter can give and it also tells the story of what happens to the particles after such a hit.

An emulsion is the material that coats a photographic plate, the original type of camera "negative" and in some ways still the best. Grains of silver in the coating mixture turn black when light falls on them. These form the picture. Gelatine in the mixture binds the silver grains together and "sets" the material in a smooth film (like stiff custard) when dry.

A nuclear emulsion is much the same

but it is made much thicker than the coating on a photographic plate and is stiff enough to be handled without a glass support. Instead of being super-sensitive to light it is prepared so as to be super-sensitive to a different range of energy—that ejected by charged particles from atoms that crash into the emulsion stack. These are the atomic fragments nuclear physicists are interested in: the nucleus stripped of its orbiting electrons, electrons that have lost their nuclei and are searching for another unbalanced nucleus to attach themselves to, and the various rarer sub-particles that are the most interesting of all.

To smash atoms so that the various components into which they fragment can be studied means cracking the intensely strong links that bind atoms together. This only happens when the "hammer" particles have been accelerated nearly to the speed of light; 186,000 miles/second. Physicists can now do this on Earth in the enormously expensive particle accelerators. In space the process has been going on since the beginning of time but not until now have scientists been able to take advantage of this. Great stars like the Sun are sources of particles, continuously ejecting jets of matter into space. Some of these particles, the cosmic rays, somehow (it is still far from clear how) achieve the huge speeds necessary to produce the interesting nuclear collisions that atomic physicists wish to study. It is when the cosmic rays hit the top of the Earth's atmosphere that this takes place. By placing a target above the atmosphere (as in a satellite) the process of atomic disintegration can be literally "snapped" as it occurs. This is what the Ilford emulsions do in the *Discoverer* satellites. A charged particle from space actually collides with an emulsion atom which then accommodatingly photographs its own end. The path of the entering particle, the tiny nuclear explosion that results when it hits the material of the emulsion, and the paths of the numerous fragments that then fly off in all directions—all leave distinctive trails of exposed emulsion in their wake. This is studied and interpreted under the microscope when the packet is retrieved.

These *Discoverer* emulsion stacks may even register some particles of anti-matter. These are rare and sinister atomic pieces that have opposite electric charges from the rest of nature. None has yet been found that occurred naturally. In bulk therefore anti-matter would spontaneously cause an explosion beside which H-bombs would seem trifling.

But is there a substantial amount of anti-matter in the universe? We do not know how much; perhaps the *Discoverer* emulsions will tell us.

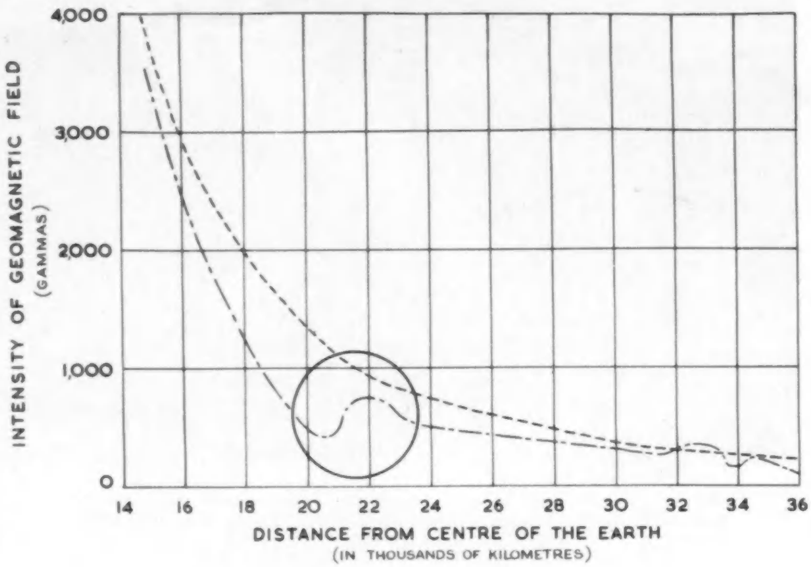


FIG. 6. Actual geomagnetic field intensity as measured by the *Lunik*'s magnetometer, plotted against theoretically calculated field strength.

Ring Current in Space?

The Russians have released the full text of the long report on space research which was delivered by President of the Academy Nesmeyanov in the spring and gave results of experiments done in their four space vehicles. The occasion was the July meeting of the cosmic-ray sub-commission of the International Union of Pure and Applied Physics (IUPAP), which was held in Moscow.

Probably the most striking announcement was the report on the magnetometer measurements from the *Lunik* space probe now assumed to be in orbit round the Sun. This revealed an unexpected drop in the geomagnetic field strength at about four Earth's radii. The position broadly corresponds with the peak in intensity in the outer zone of Van Allen radiation. The curve of measured intensity is shown, plotted against the theoretically calculated field strength at distance from the Earth, in the accompanying diagram. It may be seen that the deviations are substantial.

At a distance of between 20,000 and 21,000 km. (position ringed) it is assumed that the rocket passed through an electric-current system. This is, of course, very much farther from the Earth's surface than any previously detected layer of the ionosphere. The discovery seems to support the hypothesis of Störmer, put forward many years ago, of a ring current encircling the Earth at a considerable distance out into space. Conditions were magnetically quiet on the day of the measurements and there had not been any major magnetic disturbance for a month preceding it.

Van Allen Belt Round Jupiter?

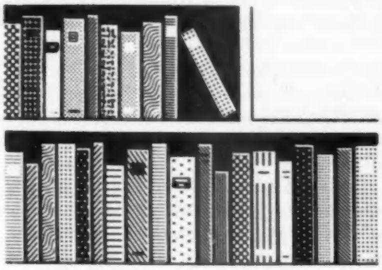
A radiation belt one hundred times more dangerous than that surrounding the Earth appears to guard the planet Jupiter from visiting space-men. The belt is thought to be 200,000 miles deep as against 20,000 for the Earth.

The discovery of synchrotron radiation from Jupiter was announced by radio-astronomers working with the newly completed 85-ft. steerable paraboloid dish at Green Bank, West Virginia, at the recent URSI meeting in Washington. Synchrotron radiation is that produced by charged particles moving at close to the speed of light in a magnetic field. These conditions are satisfied in big accelerating machines (hence the name) and also by the fast electrons thought to be the principal component of the Van Allen radiation.

A curious sequence of observations preceded this experiment. Various radio observers had "listened" to Jupiter at different wavelengths; it was found that as the wavelength increased the apparent temperature increased until Green Bank observations at 22 cm. gave a temperature of 3000°C, the kind of temperature associated with the Sun. But it is known that Jupiter is not a star but a cold body. Synchrotron radiation however occurs over a wide range of frequencies and so fits the observed facts rather well. It is suggested that there is a column density of 10^{28} particles of 5 Mev in Jupiter's "halo", moving in a magnetic field of 5 gauss.

Confirmation of the hypothesis should come from observing any time variation corresponding with the changes in the solar cycle.

THE BOOKSHELF



The Logic of Scientific Discovery

By Karl R. Popper (*London, Hutchinson, 1959, 480 pp., 50s.*)

No brief review can do this fine book justice. Perhaps the best policy for a reviewer is to sketch in the background.

During this century the world outlook engendered by fundamental physics has undergone two great revolutions: the first sprang from the theory of relativity and the second from the quantum theory. While the first upset our ideas of space, time, mass, and energy, the second was immeasurably more radical, for it struck not merely at certain scientific concepts but at scientific method itself. It did so with a two-pronged attack. On the one hand, Heisenberg enunciated his uncertainty relations and held that they defined an absolute natural barrier to human knowledge. On the other, von Neumann produced a famous mathematical proof, and the prophets of the new revolution claimed that from the empirical success of quantum theory he had proved the impossibility of a deterministic universe. There followed a number of claims exhibiting varying degrees of subjectivism or idealism. Thus, since the path of an electron could not be known, it had no path. The waves whose equations appear in wave mechanics were said to be waves of knowledge. Most remarkable of all, eminent professors of physics were to be found discussing the velocity with which the consequences of a change in our knowledge are propagated through the universe.

Today the belief is spreading among physicists that this second revolution was largely a false alarm. (It is not, of course, the physics that is disputed, but its interpretation.) During the twenty-five years or so while the neo-idealist views of the "Copenhagen School" dominated the scene, many people joined the bandwagon—nearly all theoretical physicists, a number of popular scientific writers (notably Jeans), and all kinds of thinkers from psycho-analysts to bishops who were happy to see science "abandoning materialism". Among the few who never accepted the Copenhagen interpretation was the philosopher Karl Popper (another was Einstein), and his book, "The Logic of Scientific Discovery", published in Vienna in 1934 and now available for the first time in English, must be seen as one of the great documents of the counter-revolution.

Among the achievements of the book are these: it propounds a theory of scientific method; it suggests a way around the problem of induction; it offers an interpretation of probability theory; it gives a critique of the Copenhagen interpretation of the quantum theory; and it adumbrates an alternative interpretation. Of course, not all this is of equal value (the statistician, for example, will find the work on probability and randomness of little relevance to him). However, every part of the book is fertile with ideas, and though technical, it is remarkably readable.

Finally, as in all Popper's books, the idea that knowledge advances by controversy—that is, by a process of honest and uninhibited criticism of rival theories and conscientious attention to critics of one's own theories—is not only asserted but constantly exemplified. This masterpiece should be read by all who have a serious interest in the philosophy of science.

C. S. O'D. SCOTT

Operational Research in Practice

Papers and discussions of a Paris Conference to promote and guide Development of Operational Research in NATO Countries (*London, Pergamon Press, 1958, ix+201 pp., 84s.*)

The keynote of this book is given in the foreword by Supreme Allied Commander Europe, General Norstad. He says ". . . our strength depends not alone on what we have, but to a large extent on what we do with what we have". The NATO background of the conference placed, of course, the emphasis of operational research on defence, but "what we do with what we have" is as important in industry as in defence.

Prof. Sir Solly Zuckerman gave the introductory paper. He is well known for earlier important developments he has contributed to the subject of operational research.

He drew attention to the need to relate the use of resources to the rate at which they are developing. With these must be considered the way operations occur and hence their order of complexity. A factor is, therefore, whether the end is justified by the quantitative means. This may even lead to considering the comparative value of a strategic policy or even questioning its relevance. These are steps in Zuckerman's development of the need of operational research and are vital fundamentals.

He goes on to show the importance of assessing rightness or wrongness at policy-making level before such momentum has been generated that a change can no longer be made. His conclusion is that the less known about a situation, the more—not the less—scientific attention is warranted.

This paper merits careful and detailed study and it were well that its teaching were widely known and understood in the various spheres of defence, of industry, of national Government, and not least of science itself.

Not all the papers approach this standard and none is of such general interest. Dr Lipp's paper on development planning is more concerned with industry than defence and strikes new ground. It covers both product development in the industrial field and management development in the firm itself. In the former, up to fifteen years ahead is covered; in the latter, rather less. The following important points are covered: where the group should fit in the organisation; how it should be staffed, and staff relations with other services. Rand's R. J. Goldstein's paper, "Scientific Aids to Decision-making", is a minor symposium in itself, and is good, though it is almost overshadowed by the American General Besson's brilliant contribution to the discussion—a gem of scientific military thinking. Colonel Ferré's "Evaluation of Aerial Defence" is notable for its technical elegance. Dr Benecke's "German Air Defence" is eclipsed by his fellow-countryman, Th. W. Schmidt's discussion. Dr M. M. Flood on linear programming, Dr Camp on logistic and transport operations, and R. D. Specht on war games are models of presentation, technical brilliance, and application. Dr Cole gives a good account of selection and training in the U.S.A. ORO which is most informative. P. Massé (France) "Economie et Strategie" is a sound treatment, more philosophical than technical. These are the notable papers; there are others. It is a matter for regret that Zuckerman is the only Briton to get a mention; three other British papers only rank as "also ran" with your reviewer.

It is surely a pity that national prejudice has caused some of these papers to be given in English and some in French. It is particularly strange to see French questions answered in English and vice versa. It may satisfy some supranational agreement, but it makes technical reading—and reviewing—unnecessarily difficult. This is a book for libraries and students, and a worth-while book. It is not cheap at 84*s*., but no doubt its restricted appeal and other factors made this necessary.

G. NORTON

The Young Naturalist's Year

By Fred J. Speakman (*G. Bell & Sons Ltd, 1958, 176 pp., 12s. 6d.*)

This is a book which can be heartily commended as a gift for youngsters beginning to take an interest in natural history. Unlike too many books on similar subjects, it is full of the excitement and fun of the study of living things, well conveyed by the infectious enthusiasm of the style. It is perhaps disproportionately concentrated on the mammals and birds at the expense of the plants and insects and, possibly as a result of this, it has a slight tendency to the all too common weakness of imputing human-like personalities to the wild things. The young naturalist cannot be introduced too early to the idea of instinctive and reflex behaviour and should be steered away from anything smacking of anthropomorphic sentimentality. This is a minor criticism of a book that avoids sentimentality and does not blink the fact that nature is "red in tooth and claw". One might perhaps have looked for a little more emphasis on the value of drawing and note-taking, though the author's own line drawings in the text will no doubt encourage his young reader in the right way.

Mr Speakman has received Puck's gift "to come and go and see and know" and generously has he shared it with his readers.

L. G. LOWRY

Experiments with a Microscope

By Nelson F. Beeler and Franklyn M. Branley (*London, Faber & Faber, 1958, 128 pp., illustrated, 16s.*)

This book is intended as an introduction to the use of the microscope. It is written in an easy style suitable for youngsters, and any reader equipped with a simple microscope will find it fascinating.

There are seventeen chapters, commencing with a description of the microscope and a very elementary explanation of how a microscope works. The simple and clear instructions on how to make a water-drop magnifier are excellent. They are typical of many other practical instructions which will provide hours of absorbing, spare-time occupation to any reader interested in such matters.

Simple methods for the examination of familiar objects such as print and printed illustrations, leaves, and so on, lead up to very elementary section cutting and mounting of plant stems and tissues.

A good description follows of how to make an infusion of hay and the examination of common protozoa. This is followed by inspection of textiles and fibres, moulds, yeast, and blood. There are even instructions, under the heading "Radioactivity", for the examination of a luminous watch.

The book concludes with more advanced work on examining bacteria, very simple staining, and photomicrography.

The whole subject is described with enthusiasm and in a manner of exciting exploration into a world of the "too-small-to-see" which should easily fire the imagination of a young reader.

The book should be of value to teachers of elementary science and it is never for a moment dull. For this reason alone, it would make a good present.

It is well produced, well illustrated, and available at a reasonable price.

R. MCV. WESTON

Cell Physiology

By Arthur C. Giese, (*Philadelphia and London, W. B. Saunders, 1957, xviii+534 pp., with numerous plates and figures, 70s.*)

Most of the experienced teachers of the preclinical subjects and, for that matter, of the foundations of biology, will pass through phases when they have to reformulate and alter their approach to the topic under discussion in order to keep the student interested. This is inherent in any presentation of progressing science. But not infrequently limitations are set to new ideas of presentation by the fact that the students do not have the basic training to understand completely the phenomena of, for example, electric potential differences or electron configurations of the polar and non-polar compounds. The instructor then wishes that the students sitting in front of him had learned some of the fundamental facts of physics and chemistry which would allow him to make the subject fully alive and would enable the student to extend the meaning of the facts into other fields of his studies; in other words, to enable the student to have interesting associations.

Prof. Giese, teaching Cell Physiology at Stanford University, U.S.A., must have experienced similar thoughts, and we can be grateful to him that such considerattions moved him to writing a book on the subject which can be recommended as among the best introductions for any student of medicine and biology. Each chapter is clearly written, every step is clearly developed, formulae are derived in a way comprehensible even to most of the "unmathematically" minded, and there is an abundance of clear illustrations. The whole work is so lucidly built up that it is remarkably easy to read.

The subject of Cell Physiology falls naturally into chapters: from the cellular environment, including *p*H, and so forth, the author proceeds to a chapter on the Nature of the Cell and a discussion of colloidal states. This is followed by the "Exchange of Material Across the Cell Membrane"; the next part deals lucidly with the metabolic events in cells and the "Irritability" of Cytoplasm. The nature of action potentials and their physical foundations are particularly well explained; preceding the final chapter of brief historical notes is a short discussion of cell division.

Each chapter has a list of general references and also the list of literature references to the statements in the text, so that any reader particularly intrigued by a general aspect of Cell Physiology or a specific point made in the text, will find it easy to pursue the matter further. To present the subject in the form of a manageable textbook requires by necessity subjective selections. Obviously the more difficult topics have been treated with special care, but none is neglected, though a few more pages on growth and cell division, differentiation, and related problems might be added with advantage. But it would be ungenerous to ask for all when so much is given, as there are so few points where it is easy to think of further improvements in the general tenor of the book, and as there are so few corrections to be made. The book is addressed to the young medical and biology student at the university. With our increasing specialisation we have placed on the shoulders of the biology masters the heavy burden of teaching this subject to the sixth form. If the biology teachers would read this book they would find it of great assistance in guiding those who are working for the General Certificate of Education at scholarship level. It would bring the reward to the reader that he would preserve the impression throughout his training and later stages that Cell Physiology is interesting, and it would allow him to see for himself new implications when he deals with other research problems of pathological processes. Thus the appeal of the book is not confined to the beginner, the research student in Cell Physiology or Pathology would also find it stimulating for extending his knowledge outside his own particular subject. It is the reviewer's opinion that the fascination of the subject cannot fail to be transmitted through this book to some who will be inspired to devote part of their intellectual gifts to the furtherance of knowledge beyond our present limits.

W. JACOBSON

L'Exploration des Galaxies Voisines par les Methodes Optiques et Radio-electriques

By Gerard de Vaucouleurs (*Masson et Cie in the series "Evolution des Sciences", 156 pp., 47 figures, 20 plates, 1600 fr.*)

This most recent book by Dr de Vaucouleurs on optical and radio studies of our own and neighbouring galaxies is a wel-

come addition to astronomical literature. It embraces the field of research to which the author has made many contributions in the last ten years.

We have here an account of one of the most active fields of astronomical endeavour—the understanding of the structure and evolution of the great star systems (galaxies) like our Milky Way. Those galaxies nearest our own, of which three are visible to the naked eye, have been intensely studied with the large optical telescopes and the new techniques of radio-astronomy.

The book leads into the vast expanse of extra-galactic space by way of a summary of the methods of distance measurement. All extra-galactic distances, based on the method of trigonometric parallaxes of nearby stars, have undergone severe readjustment in recent years with the use of the 200-in. telescope on Mount Palomar. The distance of M31 and M33 is now estimated at 2 million light-years, while M51, 81, and 101, which lie beyond our local system of galaxies, are at 10 million light-years.

In the 1920s Hubble classified the galaxies according to their shapes, which ranged from ellipticals through spirals to the irregulars like the Magellanic Clouds visible in southern skies. The author explains his own detailed extension of Hubble's classification of the wide variety of observed types and justifies it with many illustrations. The broad classification is not only a gradation of shapes but also shows a uniform change in physical properties. The brightness and size of a galaxy reaches a peak in the middle of the sequence; the Magellanic irregulars have spectra similar to those of younger stars and exhibit more emission line radiation than the ellipticals. Indeed, within a given galaxy there is a gradation in the emission from older to younger spectral types when going from the centre to the boundary.

One of the greatest contributions to galactic and extra-galactic studies has been made by the new discipline of radio-astronomy. Our own galaxy can be studied from end to end for the first time by observing its radio emissions which are not absorbed by the interstellar dust which confounds optical astronomers. The most detailed information in this field has been obtained from the 21-cm. spectral line of neutral hydrogen. The spiral structure of the galaxy has been adequately confirmed. Only preliminary observations of the 21-cm. emission from extra-galactic systems have yet been published, but there is evidence of a change of neutral hydrogen content with type from 1–2% in Sb spirals to 20–30% in irregular barred spirals of the Magellanic type.

The radio emission in the continuous spectrum from our galaxy is generated in the interstellar stratum by a mechanism not yet understood; the emitting medium is more extensive than the known interstellar constituents (gas and dust). This is also found in the external radio galaxies which are much larger than their optical counterparts. More sensitive optical surveys have pushed out the observed boundaries of galaxies farther and farther. For example, M32, the elliptical companion of M31, was measured by Hubble in 1926 to be 2·6′ in diameter whereas Holmberg (1950) traced it over 12′. Even so, the huge radio halo of galaxies may have no visually associated feature.

Of necessity a book written about a growing science must be dated. The recent increase of the distance scale and the important new classification of stellar populations are only touched on in footnotes. Yet the book admirably serves its purpose as an introduction to the subject for a non-specialist and is a useful reference work for the specialist. We can look forward to the projected companion volume on the collective properties of galaxies.

R. D. DAVIES

SCIENCE ON THE SCREEN

Antarctic Crossing

(35 mm. and 16 mm., sound, colour, 48 minutes, Great Britain, 1958 (*World Wide Pictures for British Petroleum Co.*)

This is a film record of the transantarctic expedition by Dr Vivian Fuchs and Sir Edmund Hillary. It opens with a reference to the landing of the preliminary party and of stores by the *Theron*, shown in the previous film *Foothold on Antarctica*, and is followed by sequences from the films of the Scott and Shackleton expeditions preserved in the National Film Archive. Sir Vivian Fuchs explains the plan of the crossing and the main party is seen arriving on the icy continent and settling in for a winter of preparation in the houses they built. As Fuchs moves off from Shackleton base on the Weddell Sea to cross the South Pole, Hillary leaves Scott base on the Ross Sea to establish depots for Fuchs on the final stages of his journey across the continent. The various incidents and momentous occasions en route are captured on film.

This excellent film succeeds in presenting some of the hazards and mishaps encountered on this historic crossing as a popular account. Though the scientific importance of the expedition is emphasised and scientists are seen adjusting equipment and taking readings, no results of any of the investigations are given. The success of the film is due largely to the skilful editing of the Kodachrome taken by George Lowe, Derek Wright, and other members of the party. Dennis Gurney, who was responsible for the editing, has achieved a remarkable continuity of action with touches of humour, and even though we see alternately the two parties approaching the Pole, there is never any confusion as to which is on the screen. The quality of the film is of a newsreel standard; the disadvantage of the hand-held cameras and colour variation—though the colour is good and in places magnificent—is countered by the authenticity of the on-the-spot photography and an ingenuity of composition in what could have been a monotonous location. The only adverse comment is in respect of the music; its apparent persistence is probably due to the unimaginative score which sometimes mimics Vaughan Williams's "Scott" music and sometimes deteriorates into an aimless strumming doodle for orchestra.

M. ESSEX-LOPRESTI

Uranium Mining

By Irene M. Spry, in the series "Geography in Colour". 27 frames with teachers' notes. (*Issued by Common Ground (1951) Ltd. Price £1 7s. 6d.*)

The strip starts with a map showing the location and surroundings of Uranium City in North-West Canada. Although a good map, it indicates the towns by initials in white on red, which does not make it very easily seen or understood. This map was probably designed for a Canadian audience, to whom it would be infinitely clearer than to an English audience.

The next few frames show the characteristics of the Canadian Shield country in winter and summer. The notes are very explicit, but they use some words such as "muskeg Marshes", "Mergansers", which are not familiar to me, although they would probably be well known to every Canadian child.

This shows that an international exchange of films and filmstrips, although highly desirable, is not always simple. An additional map and some clarification of essentially Canadian references are necessary if children are to get the best out of this strip. Undoubtedly the Uranium rush with Geiger counters replacing the sieve, and to a certain extent the pick and shovel, is very exciting.

The filmstrip shows that here is an area, far from railways and main roads, which depends upon waterways in summer and sledge with dog-teams in winter. Many of the Red Indian children have never seen a train, but take aircraft for granted.

The story is intensely interesting for young and old alike. Staking a claim is exactly the same as it was in the gold rush. Unfortunately, some of the pictures, although clear and in excellent colour, do not show the point they are supposed to illustrate, the whole weight of the message depending upon the teacher's skilful use of the notes. For example, the Geiger counter merges in colour with the background. The skis on which the aircraft is mounted are hidden by people in bright clothes, and the frame showing the staking of a claim shows a young man apparently cutting down a sapling.

The latter part of the film, however, is much more understandable, and shows the different methods of mining very clearly. It very wisely turns from methods to the human angle, and we see the way people live in and around Uranium City, how the town is growing, and once more we see the contrast between summer and snowbound winter.

All the faults are minor, and I cannot help feeling that this filmstrip, if properly used, will fascinate children of all ages. It shows that new scientific discoveries lead men to go forth and pioneer.

L. GOULD-MARKS

Science Television During June and July

Although your reviewer has often said that science television programmes should be broadcast live where possible, during June the BBC produced some excellent programmes that would not have been possible without the use of film. In each case the film had a familiar television reporter which tended to give the illusion that the broadcast was live. It is obvious that a live outside broadcast is quite out of the question when looking at animals in the swamps of South America, or when exploring the sea bed around coral islands. If, in such a film, we see a familiar figure it makes good television and feels quite different from a formal film. Excessive use of film is to be deplored, but judiciously exploited, it has its correct place.

David Attenborough continued with his exciting film stories of his searches for the rare and the unusual animal in the fetid swamps, dense forests, and extensive plains of Paraguay. His enthusiastic commentaries and the skilful photography of Charles Lagos produce an unbeatable combination.

Another fascinating film series are the underwater films of Hans and Lotte Haas. Amongst these was that devoted to the close-up photography of sharks. Mr Haas is to be congratulated on this particular report. It was more than good photography, it was a definite contribution to the study of the habits of the shark, a real contribution to the behaviour of the fish. The film showed the quiet but considerable courage on the part of the whole camera team.

A third entirely successful film programme was Aubrey Singer's "Eye on Research" broadcast of June 30, entitled *Full Fathom Five*. (This programme persists in the concoction of queer titles: surely a good programme does not need a catch-as-catch-can title.) This highly successful broadcast consisted of a report on research workers at the Scripps Institute for Oceanography at the University of California. The interviews were efficiently conducted by Raymond Baxter. A large proportion of the film used was shot on board ship and some of the tools of oceanographic research were shown. This was followed by illustrations of the remarkable hag fish, with its three

separate hearts: a fine demonstration was shown of an extracted heart, beating in saline solution and applications to cardiac studies were emphasised. We were then switched to studies on plankton, the detection of scattering layers by echo-sounding devices, and the photosensitive behaviour of krill. Then an example of chemical research was selected by a review of studies on minute quantities of growth-inhibiting organic materials in sea water and the broadcast ended with current geophysical researches on sea-bed structure and temperature. The programme was admirably planned with a well-balanced content. Inevitably, however, a few technical terminologies were not explained. Are a million viewers really expected to be conversant with the meaning of terms such as phytoplankton and zooplankton without any explanation at all? But these lapses were few and far between and did little to mar what was one of the best "Eye on Research" programmes.

June 11 saw the end of the current series of James McCloy's "Science is News". We hope that this programme will soon reappear for it has given much pleasure in the past and has usually been most informative. This programme consisted of three unrelated topics. True to its character of aiming to be a current news magazine, it brought before us, at first hand, the new Hovercraft, of which information about trials had been released merely the day before. This curious new form of transportation, invented by Mr Cockerell and undergoing development at Saunders-Roe, made an exciting subject for news reporting. Inventor and development director were interviewed and a film of the craft in motion was shown. This whole item was very spectacular and brought home the excitement of invention and development. It did not fully exploit the scientific hydrodynamics which it might well have done. It was more in the nature of an exciting news report than a scientific commentary.

It was followed by Prof. Keele who discussed "Pain" and showed some methods for trying to measure pain, and for preventing it.

The third item, introduced by Dr Margerison, began with a small model van de Graaf accelerator and led on to why a 12-million-volt machine has been installed at Aldermaston. The reason for this rather obscure point was made very clear.

This programme was perhaps in lighter vein than usual, being more entertaining than instructive, although instruction was not lacking. But it was, after all, the end of the series, and who does serious work on the last day of school term? On looking at the series as a whole in retrospect, we realise that it has taught us a great deal on a vast variety of subjects and we look forward with interest to a new session.

During July there was very little science television. ITV produced the Sunday afternoon feature "It Can Happen Tomorrow" with Gerald Leach who continues to offer simple surveys on an astonishing variety of subjects. Thus whilst the time available on July 19 was spent on railway modernisation (with such excellent detail that I suspect the lecturer is a train enthusiast), the last broadcast of the month, on the contrary was devoted to an easy discursive survey of the formidable problem of how birds and insects make their homing journeys. Mr Leach is certainly versatile.

The BBC did not give any formal studio science broadcasts at all during July but they broadcast the last programmes in the series "Look" and "Zoo Quest in Paraguay". In the former Peter Scott visited the remarkable Miami Seaquarium. In this production, which opened in the studio with an introduction from Peter Scott, we were entertained with a sound film made in the U.S.A. but whilst it was running, complete with sound track, an illuminating additional running commentary was supplied by Mr Scott. The majority of underwater films are restricted to the study of the types of animal which inhabit the particular neighbourhood, but the vast resources of the Seaquarium have brought together in one place an enormous range—turtle, shark, ray, octopus, dolphin, porpoise, and other animals—and this helps towards making this particular film somewhat unique.

We saw first a film showing how the sea-animals are trapped off the Bahamas. Then we witnessed a most extraordinary event, the performance of an underwater surgical operation for a tumour growing on the side of a large fish. It was astonishing to behold a surgeon under water, wearing diving gear, picking up scalpels from an underwater operating table, and then deftly removing the tumour (a huge chunk of swallowed lead was responsible for the growth). This most unusual film ended with shots of amusing and intelligent trick performances by dolphins.

After the film we were returned to the studio, where Peter Scott made an eloquent plea for the establishment of a seaquarium in this country.

"Zoo Quest in Paraguay" consisted of a film made by Charles Lagos with sound track, which was supported by a live running commentary from David Attenborough. It concentrated first on the natural hunting and feeding habits of a wide range of Paraguayan wild birds and then, as a contrast, showed the feeding problems encountered during the transportation of these birds back to England.

David Attenborough has a happy knack of tying up a film with actual reality. Thus we saw a shot of film from Paraguay showing some quite young guans. Then the camera switched to the studio, and there in a live broadcast we saw Mr Attenborough feeding these very guans, now grown up, and borrowed from the Zoo for this special occasion. Altogether Zoo Quest has been a happy series and the whole team engaged, Charles Lagos, Robert Walker, Natasha Kroll, Brian Branston, but first and foremost, David Attenborough, deserve congratulations on the spectacular and sympathetic way they have brought to us the entertaining habits of so many unusual animals.

S. TOLANSKY

Birthright

16 mm. and 35 mm. Black and white. Sound. 25 minutes. (*Made for Family Planning Association by Basic Film Unit.*)

There seems to me a number of possible purposes of this film. It could be an information film about the Family Planning Association; it could discuss general ideas of contraception and its contribution to welfare of individual families and of the world; it could explain how childless couples can sometimes be helped; it could show that family planning clinics supply information in a friendly atmosphere. In summary the story the film presents is as follows.

The birthright of every baby is to be wanted and loved. A baby is born—a sixth child—and is welcomed into the family. But some children arrive unwanted, and unwanted additions to the family may break a mother's capacity to care for those she has.

To one couple in ten, no child comes after marriage. The mother and father can be seen at a Family Planning Association Clinic and the causes of their failure to have children studied and sometimes such couples can be helped. The spermatozoa of the father are examined as well as the mother being seen by a women's specialist.

Unwanted children may become problem adults. Problems of sexual relationships if neglected may disturb people. Engaged couples can in groups learn about, discuss, and form conclusions on such matters including contraception for family planning.

A woman visits a FPA Clinic. The importance of the personal link between client and doctor is emphasised. There are methods of contraception which are safe, the correct use of which can be learnt. There are 300 Family Planning Association Clinics in the United Kingdom, usually in hospitals or on local authority premises.

Sir Russell Brain, Prof. W. C. W. Nixon, and Dr Alan Parkes discuss various aspects of contraception; the

Birthright
A scene from the discussion between Sir Russell Brain, Bt., D.M., F.R.C.P., Prof. W. C. W. Nixon, M.D., F.R.C.P., F.R.C.O.G., and Dr Alan Parkes, C.B.E., F.R.S., of the National Institute for Medical Research.

importance for the world of the rapid increase in population which has outpaced the increase in food production; having a further child at an interval of less than 2 years increases the dangers of childbirth; it is estimated that in this country there are 150 illegal abortions daily. Future developments will derive from biological knowledge in contrast to the mechanical and spermicidal methods in use today, and research is being done at the Oliver Bird Trust.

The commentary ends by returning again to the theme of Children by Choice not Chance, so that they arrive welcome in a happy home.

I saw this film in company with a young woman doctor, a woman medical student, and two men doctors. We thought it set out to give non-medical people an idea of what the Family Planning Association does and how it does it, that it resembled a television item and that it could be used to meet the needs of a number of different possible audiences, but that it was not ideally suited to any of the purposes mentioned at the beginning of this review. If it is to be used to start discussion about the value of contraception, it is unnecessary to show so much of what happens when a woman goes to a clinic. The clinics shown are unassuming places of a type familiar to many women, who I suppose are used to talking separated only by a screen and two yards from the benches of other waiting clients. Certainly to see what happens when you visit a clinic will disperse the fears of those who hesitate to go to get information they want because they are uncertain of what will happen inside the door. But an intelligent mother who wants to learn how to plan her family will not like being equated to the problem families shown early in the film.

The contrast of the situation of the couple who are childless with that of the mother and family broken by too frequent arrival of new children is dramatic and emphasises the tragedy of both these situations. They are, however, different problems; and the couples who want advice about one are not particularly interested in the converse problem. This film deals with both problems because this is a film to describe the Family Planning Association's activities.

There is nothing wrong in an advertising film to get support, money, and additional lay workers for the FPA, but if the object of the film is to help married couples to get guidance in family planning it might have mentioned other sources of sound help. Some family doctors themselves advise their patients about contraception; there are hospital clinics for sterility, and there are the 300 FPA Clinics.

Family Planning is an immensely important subject and one must welcome any film, any publication, that will increase knowledge and promote discussion about it. I have written at length because I don't want to say, what I think, that from Sara Erulka this is a disappointing film. Nor is it rescued by Suschitsky; the general impression is of cramped clinics (and a very scruffy laboratory) and there is a distracting shot where the doctor lifts her papers to reveal what at first seems to be a collection of coins but which I think were blots on the blotting-paper. There is much of great factual interest to be gathered from the three distinguished specialists' discussion and this was not always very easy to hear.

In brief, while rather unbalanced in its proportions, this unassuming film gives a picture of the activities of the Family Planning Association and could be usefully employed to show in women's clubs and institutes of many sorts.

R. C. MAC KEITH

Index of Chemistry Films

By the Royal Institute of Chemistry (*R.I.C., 1959, 150 pp., 5s.*)

When the historian of scientific films comes to look at the published works on the subject over the past years he will find some fields well documented and others scarcely at all. We who are engaged in the day-to-day struggle to produce worthwhile documentation are unable to see reasons why, for example, films on chemistry should be well documented and say physics hardly at all.

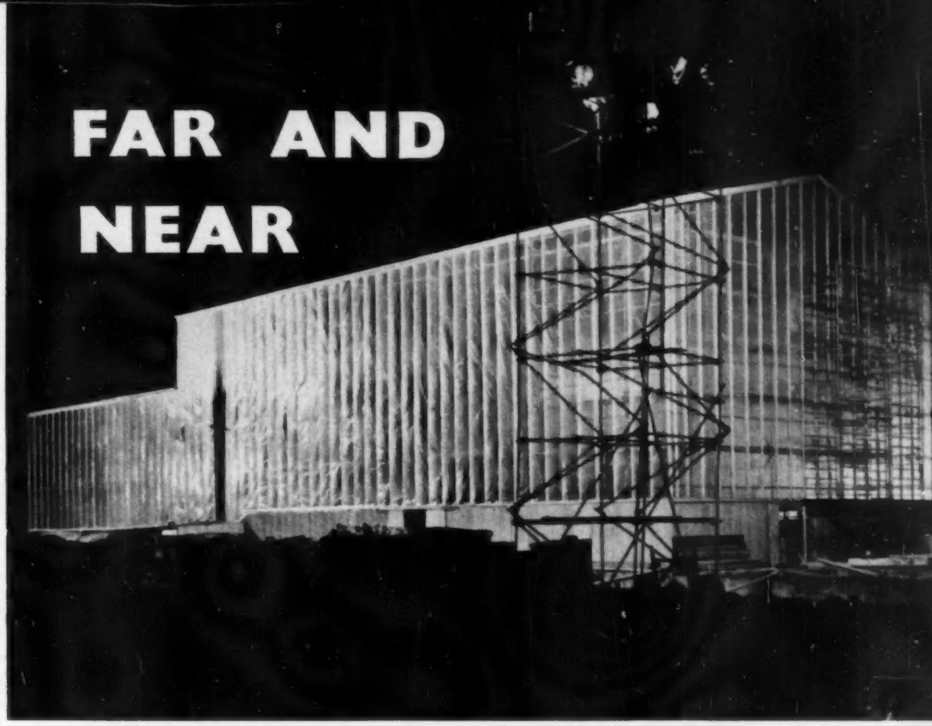
The appearance of a new work of this kind is of great interest to the critics. Here is the most elaborate and expensive catalogue to date. It is an artistically covered index, well produced and printed so that it is churlish to complain about mistakes, hasty preparation and insufficient research. However, it should be placed on record that the book pays no acknowledgement to the pioneer work of the Scientific Film Association's Catalogues upon which this work is based, editions of which date back many years.

The biggest single weakness of this index is that the country of origin and year of production for the films has been omitted. A further point open to question is the rather curious layout of the film data, which seems to have no logical sequence. The wide definition of chemistry films adopted by the author leaves the work wide open to criticism. If on page 43 seven films are included on Water Supply, why omit the Metropolitan Water Board's "Rain upon one City"; likewise on page 47 if "Bricks" is considered a fit subject for chemistry then surely "Salt Glazed Pipes", which is omitted, is also.

A number of films are included which have sometimes been withdrawn by their owners like the films from the GB Film Library on Eminent Scientists. A number of films like "Warburg Manometer" have, on the other hand, been omitted. It would also be fair to users of the catalogue if it were made clear that the films held by the Royal Institute of Chemistry itself and designated "free" are only thus to members.

F. BAMPING

FAR AND NEAR



BEATING THE WEATHER

Faced with the problem of building a vital part of a contract in half the scheduled time during the winter, Tarslag Ltd built this protective "Visqueen" polythene sheeting envelope round the building project.

The contractors were putting up the control-room buildings of a new power station at Greatham, West Hartlepool, for the South Durham Steel & Iron Co. Ltd.

Airfield and Arctic Institute at Spitsbergen

Norsk Polar Navigasjon A/S, the private company which is to build a civilian airfield on Spitsbergen, has suggested the establishment there of an Arctic Institute which should bear the name of Roald Amundsen. The Company's plans involve the construction of a building which during the summer months is to serve as an up-to-date hotel, as well as housing the Arctic Institute. During the long winter season, however, it would be entirely at the disposal of scientists and students in that Arctic region.

The primary task of this Roald Amundsen Institute is meant to be of a technical nature, that is, construction of buildings and airfields in Polar regions, transportation techniques, Polar navigation, and Arctic survival.

It is planned to erect the building at Ny Ålesund, where the airfield is now being worked on. It is hoped that work can commence next summer, and that a runway of 1600 m. can be built during the two to three summer months.

Atomic Icebreaker Nearing Completion*

The atomic icebreaker *Lenin*, which is designed for Arctic navigation in any weather or sailing conditions, is provided with the most up-to-date navigation aids, Academician Anatoly Alexandrov, the well-known Soviet physicist, says in the newspaper *Sovietsky Flot* (*Soviet Fleet*).

The ship was launched a year ago and is now nearing completion. The assembly of all three reactors has been completed and work is now under way on the interior finishing and fittings. Tests of the machinery were started in October.

The *Lenin* is fitted out with close- and long-range radar units. Her shaft power of 44,000 h.p. is double that of the biggest existing icebreaker.

When designing this giant vessel, which is capable of sailing for a whole year without refuelling, special attention was given to the selection of the best configuration for the bow. The chosen form increases the vessel's relative pressure on the ice by 15%, as compared with conventional icebreakers. This was proved during model tests in the ice reservoirs of the Arctic and Antarctic Research Institute, and also during tests in real ice.

Preliminary calculations of her ability to negotiate the ice, the Academician says, have shown that the selected pressure of 330 tons ensures the ship a steady speed of 2 nautical miles in a solid icefield up to 2 m. 40 cm. (over 8 ft.) thick. In the open sea the maximum speed of the ship will be 18 nautical miles.

A new grade of steel has been developed for the ship with a higher impact strength and good welding properties, as well as a sufficient resistance to fissioning under low temperatures. A 36- to 52-mm. ice-belt girdles the ship's hull. She has eleven main watertight compartments, and will not capsize even if two of them are flooded.

The hull was designed on the basis of experience gained from all the known icebreakers.

* *See* DISCOVERY, 1958, vol. 19, No. 12, p. 498.

National Lending Library for Science and Technology

The Department of Scientific and Industrial Research will take over part of the former Royal Ordnance Factory at Thorp Arch, near Boston Spa, Yorks., for the use of the new National Lending Library for Science and Technology. Present proposals indicate that the library will begin operating at Thorp Arch in 1961 and become fully operational during the following year. Existing large single-storey buildings will be converted into offices and book stores, and the site provides adequate room for expansion in the future.

The new library, the nucleus of which already exists in the DSIR Lending Library Unit now at Chester Terrace, Regent's Park, London, will cover all subjects in science and technology, except for some fields of medicine. It will take over the responsibility for the lending service now provided by the Science Museum Library, which in future will concentrate on serving the needs of the enlarged Imperial College of Science and Technology. It is also taking over some of the literature now held by the Science Museum Library.

The present Lending Library Unit has been collecting literature for the National Library since 1957. It already operates a loan service for Russian literature which is being progressively extended to cover publications from other countries. Eventually, much of the scientific and technological literature in the world will be included in this collection, to make it the most comprehensive of its kind in the United Kingdom.

The new library in Yorkshire will make its unique collection available to research, industrial, educational, and other organisations by loans and photographic reproduction. Its primary objective will be to encourage the greater use of scientific and technical literature. One important activity will be the expansion of work on the translation of Russian scientific literature, now organised by the Lending Library Unit in collaboration with the National Science Foundation in the United States.

Rainfall Predictions

Predictions of rainfall for the next ten years are being carried for thirty selected stations throughout the United States. Dr

View of a dam filled with water which stretches 150 ft. across the Los Angeles River, U.S.A. It is designed so it can be collapsed when flood danger arises and is made from nylon coated with neoprene. The dam is 8 ft. in diameter and holds 50,000 gallons of water when filled to capacity. It can be collapsed in ten minutes.

Charles G. Abbot, a research associate of the Smithsonian Institution, is carrying out these forecasts.

The work, which is partly financed by the Association for Applied Solar Energy, Phoenix, Arizona, is based on cyclic variations, first found in solar radiation, a field in which Dr Abbott is an expert. It has been found that identical cycles occur in published weather records.

Extensive electronic computations are required, and these are being carried out at Arizona State College. The complications involved in the calculations are very great, and results are affected by many strictly local factors. However, in the past Dr Abbot has made long-range rainfall predictions for Albany, Washington, Charleston, St Louis, Peoria, St Paul, Omaha, Brownsville (Texas), and Natural Bridge (Arizona); on the whole, these predictions have been quite successful and have certainly revealed general trends.

In his recent autobiographic book, Dr Abbot says that, when he finishes his present forecasting work, he intends to draw seasonal maps, for ten ensuing years, of the whole of the United States in order to see what percentage of the country differs from normal precipitation.

Dr Abbot says he has discovered that the sun's variation of radiation

> "comprises a master cycle of exactly 23¼ years and that there are over 60 harmonic periods thereof, such as 91 months, 68¼ months, and many others.
>
> "Each one of at least a score of these periods in solar variations is reflected by the same period in weather, both in temperature and precipitation. However, the atmosphere changes in transparency and otherwise from time to time, thereby producing lags in the effects of solar changes. These lags differ at different times so much that anyone hoping to find these periods in weather easily could be disappointed.
>
> "I worked four years on the records of precipitation at Peoria, Illinois, before I found all the pitfalls disguising the influence of solar variation. The records of over 1000 months at Peoria were tabulated fourteen times. Eventually it was found that winter, summer, and autumn must be treated separately, times of numerous sunspots must be separated from times when sunspots are few, and tabulations must be made separately before and after 1900 because of changes of buildings, machines, and population."

Essentially this time procedure must be followed for each of the thirty stations with which Dr Abbot is now working, but with the help of the most modern electronic calculators which were not available for much of his previous work.

Expedition Finds Fossil of Marsupial Lion

An expedition to Lake Eyre Basin in the far north of South Australia has brought back rare fossils, including that of a marsupial lion, believed to be many millions of years old.

The skull and part of the skeleton of the *Thylacoleo*, or Australian marsupial lion, was found. The skull was well preserved, with teeth more than an inch and a half long.

Previous expeditions to this remote area have unearthed skeletons of another prehistoric animal, the Diprotodon, a giant marsupial.

The latest expedition was a joint venture by the University of California and the Adelaide Museum led by Prof. Stirton, of the University of California.

Earthquake-proof Nuclear Power Station for Japan

The General Electric Company Limited of England has been selected to negotiate a contract for the building of Japan's first nuclear power station at Tokai Mura, sixty-five miles north-east of Tokyo. The design submitted by GEC in collaboration with Simon-Carves Limited has been approved by the Japan Atomic Power Company and will form the basis for the negotiations. It is hoped that the details of the contract, the total value of which will be about £30 million, will be finalised later this year.

In this event, GEC, as main contractor, will be responsible for the design of the entire project. Certain items, however, will be manufactured by Japanese firms working to the Group's designs. In this connexion, GEC has recently concluded, subject to Japanese Government approval, a long-term licensing agreement with a consortium of fourteen leading Japanese Companies known as the First Atomic Power Industrial Group (FAPIG). Apart from manufacturing responsibilities, members of this group will also undertake the site construction work in which they will act under the direct supervision of experienced engineers from GEC and Simon-Carves.

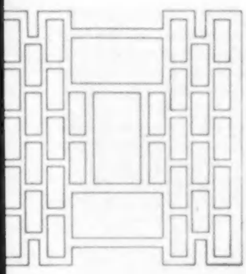
The power station, which will have a net electrical output of 150,000 kW, will be powered by a single gas-cooled graphite-moderated reactor of the same basic type as the two reactors at present being built by the Group at Hunterston in Scotland. Many novel features have been embodied in the design, however, particularly with regard to structural and control considerations, in order to ensure the safety of the installation under earthquake conditions.

The station will take approximately four years to build and is expected to be in operation by mid-1963.

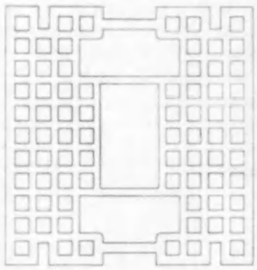
New Scheme for University Students

At the beginning of this year, nineteen undergraduates began a week's vacation course with Pfizer Ltd, manufacturing chemists. At the end of the course they told senior executives of the company what they thought of the firm and its activities. Frank discussion was encouraged.

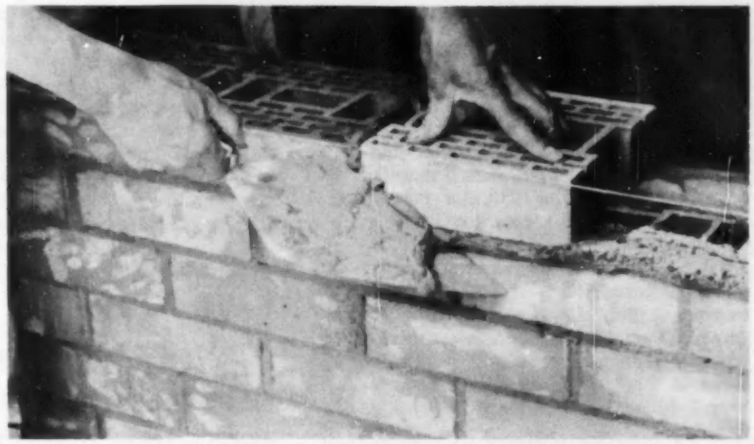
The undergraduates were from Oxford,



V5



V6



A new type of hollow clay brick—which forms a cavity wall in one unit without ties—has been designed and developed at the Building Research Station. The hollow brick completely changes the traditional British pattern of clay brick which has existed in its present form for hundreds of years. Yet only a comparatively small change in technique will be required by the bricklayer.

A group of four bungalows, designed by Mr F. B. Pooley, F.R.I.B.A., Consultant Architect to the Aylesbury Borough Council, is the first building in this country to be constructed with the new type of bricks.

The bricks are perforated and are therefore lighter than the standard solid brick, volume for volume; this should lead to quicker laying. The air spaces in the bricks provide the necessary thermal insulation and assist the manufacturer in drying and firing. The design also lends itself to mechanised production.

Cambridge, Glasgow, Cardiff, and Aberystwyth. A notable feature of the course was that undergraduates reading for arts as well as scientific degrees were included.

The aim of the scheme, which was supported by the University Appointments Boards, was to provide general background experience of the chemical manufacturing industry. The students toured the plants and laboratories, met production, research and sales staff, and obtained as much information and advice as possible from department heads.

Typical subjects they studied and later discussed were the functions of production control, the work of a project engineer, and how to launch a new product.

All undergraduates selected for the course were in their final year and will shortly be taking up a career.

New Underwater Organisation

A new international organisation with the rather unusual name of "Confédération Mondiale des Activités Sub-Aquatiques" (International Underwater Confederation) has just come into being.

It was founded at a recent meeting in Monaco by delegates of national federations of skin-divers and undersea explorers from Belgium, Brazil, France, the Federal Republic of Germany, Greece, Italy, Malta, Monaco, Poland, Portugal, Spain, Switzerland, the United Kingdom, the United States, and Yugoslavia.

Two committees have been set up by the confederation, one devoted to underwater sports and the other to technical problems involving underwater photography, archaeology, biology, and speleology.

Preventive Criminology

The Société Internationale de Prophylaxie Sociale will be convening the First International Congress on Criminal Reform in Paris, September 27–30. The Society is concerned with combating crime at the source. The Congress will therefore consider such factors as the environment and psychology of the criminal and delinquent, his standard of living and education, and elements in our society and economic structure which may contribute to or discourage crime. Demographic and ecological aspects will also be considered in addition to such topics as the commercial aspects of crime, and the effect of publicity, alcohol, and drugs.

Unusual Colouration on Jupiter

From time to time decided colours are seen on the disc of Jupiter. It has been suggested that these colours are less vivid than was the case half a century ago, but they are still discernible, and, of course, the Great Red Spot often shows its characteristic hue. In 1958, for instance, the Spot was strongly pinkish.

In the spring of 1959 several observers noted a remarkable orange-yellow hue covering the whole equatorial zone of the planet, including both the Equatorial Belts. It was seen in March by observers in Britain and South Africa; a very early observation by Patrick Moore (mid-March) gave the colour as "strong yellow, perhaps slightly orange". The appearance was seen at about the same time by W. E. Fox and others, who, however, described it as rather more orange than yellow. In May the colour faded, to return in early June before fading once more.

The phenomenon seemed to be a high-altitude one, situated in the upper atmosphere of Jupiter; the impression was of an obscuration covering the whole region (System I). It is also worth noting that the Red Spot, which lies well to the south, has disappeared completely—as it does, from time to time—though the Red Spot Hollow is still visible.

The precise nature of the phenomenon is uncertain, but although it is certainly not of fundamental importance it merits close study. The behaviour of this zone of Jupiter during the coming months will be of considerable interest.

Science in Parliament: June 22–July 30

In the last weeks before the summer recess, questions were asked on such varying subjects as research into low-temperature carbonisation (June 22), effects of radioactivity on people living at different altitudes (June 23), research into human problems by the National Coal Board (June 29 and July 6), the electronic stethoscope (June 29), research into chemical by-products of coal (July 6), progress in studying various schemes for nuclear propulsion (July 8), and the incidence and countering of atmospheric pollution from motor vehicles (July 14 and 21). There was a particularly interesting reply by the Minister of Supply (July 3) to the effect that in the last ten years the Ministry had spent some £550 million on aeronautical research and development.

In a debate (July 14) on the White Fish and Herring Industries, considerable concern was expressed by a number of members about the adequacy of research:

for example, was the "disappearance of the herring" a man-made phenomenon or the result of natural causes? The Minister of Agriculture and Fisheries, in his reply, denied that we were "playing with research". About £1 million annually was being spent: this included marine biological research. He also claimed that our scientists were playing a major part in international developments for fish-conservation.

July 1 saw the recommittal of the Nuclear Installations (Licensing and Insurance) Bill after its amendment in Standing Committee. Among a number of important amendments which were accepted were clauses to allow a more liberal limitation of time for a claim resulting from an incident, and to provide complete control by the State of fissile substances such as plutonium produced as the result of research, the purpose being to ensure that private and university research could be undertaken, even though these did produce small quantities of fissile material. In moving the third reading, the Parliamentary Secretary to the Ministry of Fuel stated that though the Bill was not retrospective, the Atomic Energy Authority did not intend to invoke the existing law of limitation to protect itself against any claims arising out of the Windscale accident. Finally, he announced that Major-Gen. S. W. Joslin would become Chief Inspector of Nuclear Installations.

July 1 saw an Adjournment Debate on the Nuclear Power programme. The member raising this was concerned to urge a re-appraisal of the post-1965 programme. Some of the earlier economic assumptions had been misleading: the costs of conventional power stations had been over-estimated, while those of nuclear power stations had been under-estimated. He cited a speech by Sir Christopher Hinton to the effect that the break-even date for nuclear stations could not now be before 1970. In his reply, the Parliamentary Secretary to the Ministry of Fuel conceded that while it was true that for conventional stations the cost per unit would be 0·50*d*. to 0·65*d*. and for nuclear stations 0·65*d*. to 0·70*d*., further economies in the conventional Calder Hall-type station were virtually certain. Moreover, no allowance had been made for newer developments such as the advanced gas-cooled reactor, the fast-breeder reactor, not to mention the possibilities from fusion.

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Liquid asset

Our ancient forefathers were laughably ignorant of the quantum theory, television and man-made satellites. But when it came to the transport of liquids they knew a good thing when they saw one. The goatskins they used were light and strong, and when empty they could be carried home easily. The virtues of the goatskin are beginning to be appreciated again in an age when all kinds of liquids from formaldehyde to fruit juice, are carried in bulk over long distances by road, rail and sea in special vehicles, which must often return home empty. Marston Excelsior Ltd., an I.C.I. subsidiary with great experience of making flexible fuel tanks for aircraft, has solved the problem of the unprofitable return journey by building flexible tanks that can be carried on conventional lorries, rail waggons or barges. These ' Portolite ' tanks, made of fabric sandwiched between layers of rubber-like material, hold with equal safety anything from acids to drinking water. When emptied, they can be unlashed and rolled up to make room for a payload of a different kind.

Thus, and in a thousand kindred ways, I.C.I.'s research and production are serving the Nation.

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